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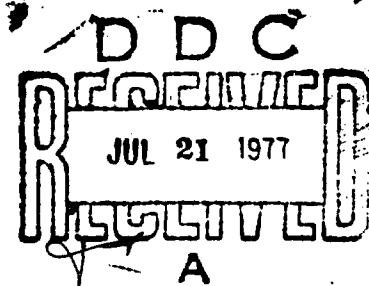
WHITE OAK LABORATORY

PREDICTION OF IMPACT PRESSURES, FORCES, AND MOMENTS DURING VERTICAL AND
OBLIQUE WATER ENTRY

15 JANUARY 1977

NAVAL SURFACE WEAPONS CENTER
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cones, disks, and cusps. Surface pressures agree well with measurement reflecting both the model geometry and location on the model. The calculated drag and lift exhibit close agreement with experimental values, particularly prior to the peak loads. At later times the shape of the hydraulic cavity must be taken into account and an approximate procedure for doing this is described. A computer code listing and sample computer runs are provided as well as instructions for using the code.

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15 January 1977

PREDICTION OF IMPACT PRESSURES, FORCES, AND MOMENTS DURING VERTICAL AND OBLIQUE WATER ENTRY

This report describes a method for predicting pressures, forces, and moments on arbitrary bodies during vertical and oblique water entry. Also included is a listing of the computerized form of the technique, sample computer runs, and user instructions.

This work was supported by NSWC/WOL internal research funds and by NAVSEA Code 03512 under tasks SR12301/02. The authors would like to acknowledge Dr. Thomas Peirce of NAVSEA for his advice and continued interest in this effort.

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LIST OF SYMBOLS

C_p	pressure coefficient $(p - p_\infty)/(1/2 \rho V_I^2)$
C_{D_∞}	drag coefficient assuming a constant model velocity
C_D	$(\text{drag force})/(1/2 \rho V_I^2)/(\pi D^2/4)$
C_X	$(\text{force along x axis})/(1/2 \rho V_I^2 \pi D^2/4)$
C_N	$(\text{force along y axis})/(1/2 \rho V_I^2)/(\pi D^2/4)$
C_{MX}, C_{MY}, C_{MZ}	$(\text{moment about the x,y, and z axis respectively})/$ $(1/2 \rho V_I^2)/(\pi D^3/4)$
C_w	wetting factor, h/h'
D	model diameter
\bar{e}_n	unit vector normal to the body surface
\bar{e}_v	unit vector parallel to the entry velocity vector
\bar{k}	unit vector in the z direction
h	model depth below effective planar surface (see Fig. 1)
h'	model depth below original surface (see Fig. 1)
Δh	increment in effective depth between successive steps
N	number of elements in the model
p	pressure
r	$\sqrt{x^2 + y^2}$
t	time
t_m^*	$V_I t/D$ where t is measured from initial model impact
t_c^*	$V_I t/D$ where t is the length of time the element centroid has been submerged
t_e^*	$V_I t/D$ where t is measured from initial impact of the element
V	fluid velocity = $-V\phi$

LIST OF SYMBOLS (Continued)

V_I	initial entry velocity of center of gravity
V_E	velocity of points on the model surface
V_s	surface velocity
V_p	velocity of the deepest point on the model
V_ξ, V_η, V_γ	velocity component in the element coordinate system (ξ, η, γ)
x, y, z	water surface coordinate system which is located on the surface at the point of initial model contact with the water (see Fig. 1)
x', y', z'	model fixed coordinate system (see Fig. 1)
x'', y'', z''	see Fig. 6
x_{cp}	(center of pressure measured from the model nose)/d
z_c	depth of element centroid
α	see Fig. 25
β	$\tan^{-1}\{-y'/r\}$
θ	entry angle (measured from the horizontal)
θ_c	cone half angle
θ_l	$\tan^{-1}(dr/dz')$ where z' is axial distance along the entry body and r is the local body radius
ξ, η, γ	element coordinate system. The γ axis is perpendicular to the element surface while η and ξ are in the plane of the element
ρ	density
ϕ	velocity potential
Superscript	
\wedge	nondimensionalized - see Eqs. (6)

INTRODUCTION

A common problem in the design of bodies which enter the water at high speeds is the determination of the surface pressures, forces and moments during water impact. This paper describes an engineering method for calculating these quantities. A simplified potential model is used which replaces the water's free surface with an effective planar surface that is positioned using an empirical parameter available in the literature for a wide variety of shapes. To confirm predictions, calculations are compared to experiment for the oblique entry of spheres, disks, and ogives and for the vertical entry of spheres, cones, ogives, and cusps. Surface pressures agree well with measurement reflecting both the model geometry and location on the model. The calculated drag and lift exhibit close agreement with experimental values, particularly prior to the peak loads. At later times the shape of the hydraulic cavity must be taken into account and an approximate procedure for doing this is described. A program listing and sample runs are provided as well as instructions for using the code.

Attempts to analyze the water-entry problem originate circa 1929 with the work of von Karman¹. Comprehensive surveys of this field are provided by May², Thigpen³, Szebehely⁴, and Moran⁵. The main thrust of early work follows the formulation developed by von Karman and Wagner⁶. In this approach a potential

¹von Karman, T., "The Impact on Seaplane Floats During Landing," NACA TN 321, Oct 1929

²May, Albert, "Forces at Water Impact," Alden Research Laboratories, ARL 119-72/SP, Dec 1972

³Thigpen, A., "Water-Entry Technology - A Review," Sandia Corporation Technical Report SC-Dr 71 0196 (Jun 1971)

⁴Szebehely, V. G., "Hydrodynamic Impact," Appl. Mech. Rev., 12, 297-300, 1959

⁵Moran, J. P., "On the Hydrodynamic Theory of Water Exit and Entry," Therm Advanced Research Technical Report TAR-TR 6501 (Mar 1965)

⁶Wagner, H., "Über Stoss-und Gleitvorgänge an der Oberfläche von Flüssigkeiten," ZAMM 12, 4, 193-215, 1932

flow model is used and forces are calculated by the added mass concept. The submerged portion of the body is often fitted or replaced by another with the same surface cross-sectional area for which a closed form solution is available. A linearized version of the free-surface boundary conditions is applied to determine the surface shape. Most of the theories are restricted to vertical entry of simple geometries. In recent years, computational efforts have been made to obtain a solution using the non-linear boundary conditions. An early example of such work is that of Chu and Falconer⁷. A relaxation method was used to solve the potential problem for arbitrary bodies. This project was abandoned due to problems with excessive computational time and surface contact discontinuities. The same formulation for the vertical entry of cones has been treated by Weber⁸ using a distribution of source dipoles. More recently, Shere and Vander Vorst⁹ and Vander Vorst and Rogers¹⁰ have used the marker and cell method to develop a detailed viscous model of vertical cone entry.

The objective of the current study has been to develop an engineering tool for calculating pressures and loads which is simple to use, inexpensive to exercise, and applicable to a wide variety of geometries. Accordingly, the philosophy of the current program has been to include only those portions of the problem which can be shown empirically to be necessary. The current work combines a simple flow field model with the potential flow computational techniques of Hess and Smith¹¹ to form an extremely versatile approach which can be applied to a wide variety of geometries over a broad range of entry conditions. The success of this calculative method indicates that a detailed description of the free surface is not necessary for the purposes of calculating entry pressures and loads.

⁷ Chu, W. -H., and Falconer, D. R., "Further Development of a More Accurate Method for Calculating Body-Water Impact Pressures," Southwest Res. Inst. Tech. Report No. 5, 1963

⁸ Weber, C. F., "The Vertical Water Entry of a Cone," NOLTR 69-26, Jan 1969

⁹ Shere, K. D. and Vander Vorst, M. M., "Vertical Water Entry of Finite Cones - A Numerical Calculation," Naval Surface Weapons Center, White Oak Laboratory, NOLTR 73-22, 1973

¹⁰ Vander Vorst, M. J., and Rogers, J. C. W., "Calculation of Vertical Water Entry by the Partial Cell Marker and Cell Method," Proceedings of the 1976 Heat Transfer and Fluid Mechanics Institute, McKillop, Vaugh, and Dwyer, Stanford U. Press 1976

¹¹ Hess, J. L. and Smith, H. M. O., "Calculation of Potential Flow About Arbitrary Bodies," Progress in Aeronautical Sciences, Edited by D. Kuchemann, Vol. 8, pp 1-138, 1967, Pergamon Press, New York, New York

PROBLEM FORMULATION

The flow field about the entering body is assumed to be described by a potential model. The free surface is simulated with an effective planar surface whose location is defined using the measured wetting factor C_w . This parameter is equal to the ratio of h/h' where h is the effective depth of the model and h' is its actual depth or penetration below the original free surface (see Fig. 1). The governing equations and boundary conditions are:

Governing equation: $\nabla^2 \phi = 0$ (1)

Boundary conditions:

(a) On body surface: $-\nabla \phi \cdot \bar{e}_n = \bar{V}_E \cdot \bar{e}_n$ (2)

(b) On the effective planar surface:

$$\left\{ \begin{array}{l} v_s = -(C_w - 1) \bar{V}_p \cdot \bar{k} \\ \phi = 0 \end{array} \right. \quad \begin{array}{l} (3a) \\ (3b) \end{array}$$

Pressures are calculated from successive solutions at differing depths using the unsteady Bernoulli equation:

$$\frac{p - p_\infty}{\rho} = \frac{\partial \phi}{\partial t} - \frac{1}{2} (\nabla \phi)^2 \quad (4)$$

This equation must be cast in body fixed coordinates since ϕ is calculated at the same point on the body in successive steps. Thus, equation (4) becomes:

$$\frac{p - p_\infty}{\rho} = \frac{\partial \phi}{\partial t} - \bar{V}_E \cdot \nabla \phi - \frac{(\nabla \phi)^2}{2} \quad (5)$$

The above problem can be put in nondimensional form by applying the following transformations:

$$\begin{aligned} \hat{\phi} &= \phi / V_I D \\ \hat{x}, \hat{y}, \hat{z} &= x/D, y/D, z/D \\ \hat{h} &= (\bar{V}_p \cdot \bar{k}) C_w t V_I / D \\ \hat{v}_s &= v_s / V_I \quad \hat{v}_p = \bar{V}_p / V_I \quad \hat{v}_E = \bar{V}_E / V_I \end{aligned} \quad (6)$$

Now equations (1) through (3) become:

$$\nabla^2 \hat{\phi} = 0 \quad (7)$$

$$-(\nabla \hat{\phi}) \cdot \bar{e}_n = \bar{e}_n \cdot \hat{V}_E \quad (8)$$

$$\left. \begin{aligned} \hat{V}_s &= -(C_w - 1) \hat{V}_p \cdot \bar{k} \\ \hat{\phi} &= 0 \end{aligned} \right\} \text{ on effective planar surface} \quad (9)$$

The nondimensional pressure is:

$$C_p = 2 \frac{\partial}{\partial t} [(\hat{V}_p \cdot \bar{k}) t C_w] \frac{\partial \hat{\phi}}{\partial h} - 2 \hat{V}_E \cdot \nabla \hat{\phi} - (\nabla \hat{\phi})^2 \quad (10a)$$

For constant entry conditions (i.e., \bar{V}_p and C_w are fixed) the above becomes:

$$C_p = 2 C_w \sin \theta \frac{\partial \hat{\phi}}{\partial h} - 2 \bar{e}_v \cdot \nabla \hat{\phi} - (\nabla \hat{\phi})^2 \quad (10b)$$

These two equations indicate that the calculated pressure and force coefficients are independent of the model and entry velocity scale (i.e., D and V_I respectively). The value of these two parameters must be simulated through an appropriate choice of C_w . Also it is evident that for constant entry conditions, depth, not time is the most natural independent variable.

The boundary conditions used in the current study are similar to the linearized version applicable to slender bodies. The linearized conditions are that:

$$\phi = 0 \quad \text{on} \quad z = 0 \quad (11)$$

$$\bar{V}_s = - \frac{\partial \phi}{\partial z} (x, y, 0) \bar{k} \quad (12)$$

These conditions follow from the nonlinearized form by dropping the quadratic terms which are second order as long as ϕ and its derivatives are small near the surface. The present model applies an empirical correction to the surface velocity described by equation (12).

POTENTIAL FLOW SOLUTION

At each depth the problem requiring solution is described by equations (7) through (9) and is directly amendable to the potential flow techniques developed by Hess and Smith which use a distribution of sources and sinks. The surface of the body under consideration is divided into quadrilaterals and a constant source strength is assumed to exist throughout each element. The source strengths are determined by satisfying equation (8) at the centroid of each element which results in a system of N simultaneous equations of the form:

$$\sum_{j=1}^N A_{ij} \sigma_j = \bar{V}_E \cdot \bar{e}_{n_i} \quad (13)$$

Here σ_j is the source strength of element j , \bar{e}_{n_i} is the unit vector normal to element i , and A_{ij} is the normal velocity induced on element i by unit source strength on element j . Equation (13) is solved directly using the method of reference 12. When the number of elements exceeds 120, solution is accomplished using a series of blocks.

Once the source strengths are determined, the velocity and potential at the centroid of each element can be calculated:

$$\begin{aligned} v_{\xi_i} &= \sum_{j=1}^N B_{ij} \sigma_j \\ v_{\eta_i} &= \sum_{j=1}^N C_{ij} \sigma_j \\ \phi &= \sum_{j=1}^N D_{ij} \sigma_j \\ v_{\gamma i} &= \bar{e}_v \cdot \bar{e}_{n_i} \end{aligned} \tag{14}$$

Here B_{ij} , C_{ij} , and D_{ij} represent the quantities V_ξ , V_η and ϕ induced on element i by element j assuming element j has a source strength of one. The term of matrices $[A]$, $[B]$, $[C]$, and $[D]$ are evaluated using the closed-form expressions given in reference 11 which are reproduced in Appendix A. Equations (13) and (14) are cast in the inertial frame of reference where $V_\infty = 0$.

In applying the above method to the water-entry problem, only the submerged portion of the body (i.e., below the effective planar surface) is considered. The extra condition, $\phi = 0$, is satisfied on the effective planar surface by locating image elements above this surface as shown in Figure 2. The strength of the image element is equal in magnitude but opposite in sign to the original one.

¹² Forsythe, G., and Moler, C., Computer Solution of Linear Algebraic Systems, Prentice-Hall, Englewood Cliffs, NJ, 1967

If the entry body possess symmetry about the $y'-z'$ plane, only half of the model is gridded since symmetric element pairs have the same source strength. For such a body, four types of elements have the same source strength magnitudes and their influence coefficients are grouped together. The terms A_{ij} , B_{ij} , C_{ij} and D_{ij} reflect the influence on element i of element j , its image, the corresponding symmetric element and its image. If the entry body does not possess planar symmetry the entire face must be gridded. Here each influence coefficient reflects only the effect of an element and its image.

COMPUTATIONAL PROCEDURE

A series of points or nodes are defined on the surface of the body of interest in x' , y' , z' coordinates. These are arranged into groups of four to form planar quadrilateral elements as shown in Figure 3. The several different options available for defining nodes and elements on arbitrary bodies are discussed in Appendix C.

Solution of the Potential Problem

The entire body may have an arbitrary entry velocity and rotation in the $y-z$ plane is allowed. The computation proceeds by inserting the model into the water in a series of steps each at a depth greater than the previous one. The entry velocity and the increment in model depth can be varied from step to step. At every step the group of elements comprising the submerged portion of the model are redefined and arranged into a form amenable to the calculative procedure outlined in the previous section. The nodes defining a particular element are checked to determine whether they are above or below the water line. Elements with all four nodes above the water line are discarded while those with all four below it are included without change. Element which are intersected by the water surface may have either one, two or three submerged nodes as shown in Figure 4. In all cases two new nodes are generated. Given two nodes, one below the water surface (x_1, y_1, z_1) and one above it (x_2, y_2, z_2) the new node located at the water surface on a line intersecting these two points is:

$$\begin{aligned} z_{\text{new}} &= 0 \\ y_{\text{new}} &= y_1 + (y_2 - y_1) \frac{z_1}{(z_1 - z_2)} \\ x_{\text{new}} &= x_1 + (x_2 - x_1) \frac{z_1}{(z_1 - z_2)} \end{aligned} \quad (15)$$

When an element has only one node submerged, it is necessary to define a third new node in order to obtain a quadrilateral element. This last new node is placed midway along the surface edge of the element. If only one node is above the water surface the generation of two new nodes results in a pentalateral element. Here again, a third new node is added and the element is broken into two parts each of which is now quadrilateral.

It is necessary to define a set of element coordinates associated with each quadrilateral element used in the computations. This η , ξ , γ coordinate system is shown in Figure 5 and the corresponding unit vectors are as follows:

$$\begin{aligned}\bar{e}_\xi &= \frac{(x_3-x_1)\bar{i} + (y_3-y_1)\bar{j} + (z_3-z_1)\bar{k}}{\sqrt{(x_3-x_1)^2 + (y_3-y_1)^2 + (z_3-z_1)^2}} \\ \bar{e}_\gamma &= \frac{\bar{e}_\xi X [(x_2-x_4)\bar{i} + (y_2-y_4)\bar{j} + (z_2-z_4)\bar{k}]}{|\bar{e}_\xi X [(x_2-x_4)\bar{i} + (y_2-y_4)\bar{j} + (z_2-z_4)\bar{k}]|} \\ \bar{e}_\eta &= \bar{e}_r X \bar{e}_\xi\end{aligned}\quad (16)$$

Here the subscripts refer to the corner numbers shown in Figure 5.

At every step, equations (1) to (3) are solved using the potential flow method discussed in the last section. The value of the velocity and potential at each element centroid is stored for future use in determining C_p . In the case of elements which have been split into two (Fig. 4c), a single area weighted average value is retained.

Calculation of Surface Pressures

At each depth the pressure coefficient, C_p , is evaluated at each element centroid using equation (5) which is in a body fixed frame of reference:

$$C_p = \frac{p-p_\infty}{\frac{1}{2} \rho V_I^2} = \frac{2}{V_I^2} \frac{\partial \phi}{\partial t} + \frac{2\bar{V}_E \cdot \bar{V}}{V_I^2} - \left(\frac{V}{V_I} \right)^2 \quad (17)$$

The fluid velocity, \bar{V} , which appears in this equation is directly determined at each depth, but $\frac{\partial \phi}{\partial t}$ must be calculated using the value of ϕ at the same body locations in adjacent steps. The general expression used to calculate this quantity at the n^{th} step is:

$$\begin{aligned}\left. \frac{\partial \phi}{\partial t} \right|_n &= \dot{\phi}_{n-1} + (\dot{\phi}_{n+1} - \dot{\phi}_{n-1}) \frac{\Delta t_{n-1}}{[\Delta t_{n+1} + \Delta t_{n-1}]} \\ \dot{\phi}_{n-1} &= \frac{\phi_{cn} - \phi_{cn-1}}{\Delta t_{n-1}} \\ \dot{\phi}_{n+1} &= \frac{\phi_{cn+1} - \phi_{cn}}{\Delta t_{n+1}}\end{aligned}\quad (18)$$

Here ϕ_{c_n} is the value of the potential at the element centroid where the pressure is being calculated at the n^{th} step. The quantity Δt_{n-1} is the time interval between steps $n-1$ and n . Similarly, Δt_{n+1} is the time interval between steps n and $n+1$. Note that if $\Delta t_{n-1} = \Delta t_{n+1}$, the above expression reduces to the central difference.

$$\left. \frac{\partial \phi}{\partial t} \right|_n = \frac{\phi_{c_{n+1}} - \phi_{c_{n-1}}}{2\Delta t_{n+1}} \quad (19)$$

Special problems arise in calculating $\left. \frac{\partial \phi}{\partial t} \right|_n$ for elements which are modified (i.e., intersected by the water surface) in any of steps $n-1$, n , and $n+1$. This is because the body fixed coordinate of a modified element centroid differs from its unmodified value and hence ϕ is not known at the same point on the body surface for the required number of adjacent steps. To handle this situation local similarity is assumed. This assumption holds that at any point within an element ϕ is only a function of the length of time that this point has been submerged. This removes the necessity of knowing ϕ at the same point on the body surface. Hence the values of ϕ associated with the same element centroid are used in equation (18) regardless of whether the element is modified in any of the three required adjacent steps. If an element is modified, the associated time interval between it and preceding or following steps to be used in equation (18) is no longer the time interval between successive steps. The required time interval to be used in place of Δt_{n-1} is:

$$\Delta t = \frac{h_n - h_{n-1}}{C'_w V_z} \quad (20)$$

An analogous expression applies for determining Δt_{n+1} . Here h_n is the depth of the element centroid at step n while C'_w and V_z are the wetting factor and the z velocity component of the element centroid between steps $n-1$ and n . Since the model may rotate in the y - z plane the velocity vector of different points on the body surface will vary with location. Hence, the wetting factor C'_w used in equation (20) is a local value and not that prescribed for the entry body. Between steps $n-1$ and n this parameter is calculated from:

$$C'_w = \frac{V_z + (\bar{V}_p \cdot \bar{k})(C_w - 1)}{V_z} \quad (21)$$

where C_w is the prescribed time interval and wetting factors between $n-1$ and n . An analogous expression is used to determine C'_w between steps n and $n+1$.

For modified elements located near the water surface it is also possible to use the boundary condition $\phi_{n-1} = 0$ at $h_{n-1} = 0$. This condition must be applied if the element at which the pressure is to be calculated is not present in the preceding step (i.e., no part of it was submerged). It has also been found advantageous to use this condition for elements modified in step n .

The local similarity assumption is strictly applicable for the oblique entry under constant velocity and orientation of an infinite plate. For plates of infinite length but finite and constant cross-sectional geometry this assumption holds in $x = \text{constant}$ planes shown in Figure 6. This assumption is well founded for bodies where conical similarity is applicable if for successive steps $\Delta h \ll h$. On three-dimensional models this assumption is most accurate on portions of the model where the surface geometry varies slowly.

The pressure coefficient on the model at the water surface is singular. This can be seen by casting equation (4) in a frame of reference moving with the effective planar surface.

$$C_p = \frac{2}{V_I^2} \left[\frac{\partial \phi}{\partial t} + V_s \cdot V - \frac{(V)^2}{2} \right]$$

On this surface $\frac{\partial \phi}{\partial t} = 0$. Due to a source discontinuity at the intersection of the model and the water surface $V \rightarrow -\infty$ and $C_p \rightarrow -\infty$. Fortunately, the value of C_p recovers quickly with depth and assumes a positive value well before the experimentally observed pressure peak. For the element sizes used in this study the first value of pressure calculated for each element is usually positive.

Negative C_p values can also be obtained on the sides of the entering body if allowance is not made for the flow cavity. Such values are set to zero for the purposes of calculating total model loads.

USE OF THE NUMERICAL MODEL

In using the described numerical model it is necessary to specify the wetting factor, C_w , the increment in depth between successive steps (Δh) and to construct an appropriate grid. In some cases it is also advisable to apply a correction to the pressure calculated on modified elements. The parameter C_w can be determined from a body of existing experimental data which will be reviewed in conjunction with specific applications. The numerical effect on $C_{D\infty}$ and C_p of varying C_w is illustrated in Figures 7 and 8 respectively.

With decreasing values of C_w , $C_{D\infty}$ is reduced in magnitude and peak values occur at a later time. The peak pressure coefficient increases with increasing values of C_w , but its rate of decay is also accelerated.

Selection of Δh

The flow field properties at any particular depth are independent of solutions at other depths and hence of Δh . However, calculation of C_p , as discussed in the previous section, requires values of ϕ from adjacent steps. In as much as the present method calculates only a single pressure for each element, it is desirable that this pressure represent an average for the element. To ascertain an appropriate step size for accomplishing this, the constant velocity and orientation entry of the flat plate of finite length shown in Figure 6 is considered. Defining \bar{h} to be the depth of an arbitrary point p on the surface of the plate:

$$\left. \frac{\partial \phi}{\partial t} \right|_p = \left. \frac{\partial \bar{h}}{\partial t} \frac{\partial \phi}{\partial \bar{h}} \right|_p = C_w \sin \theta V_I \left. \frac{\partial \phi}{\partial \bar{h}} \right|_p$$

Transforming the above into the x'' , y'' , z'' coordinate system of Figure 6 which is fixed on the effective planar surface:

$$\left. \frac{\partial \phi}{\partial t} \right|_p = (C_w \sin \theta V_I) \left[\left. \frac{\partial \phi}{\partial y''} \frac{1}{\cos \theta} \right]_p$$

The average value of $\frac{\partial \phi}{\partial t}$ for the rectangular elements shown in Figure 6 with a pair of edges parallel to the water surface is:

$$\overline{\frac{\partial \phi}{\partial t}} = \frac{C_w \sin \theta V_I}{A \cos \theta} \int_{x_1''}^{x_2''} \int_{y_1''}^{y_2''} \frac{\partial \phi}{\partial y''} dy'' dx'' = \frac{C_w \sin \theta V_I [\phi^*(\bar{h}_2) - \phi^*(\bar{h}_1)]}{(\bar{h}_2 - \bar{h}_1)} \quad (23)$$

or

$$\overline{\frac{\partial \phi}{\partial t}} = \frac{\phi^*(t_2) - \phi^*(t_1)}{(t_2 - t_1)}$$

Here $\phi^*(t_1)$ and $\phi^*(t_2)$ are the average values of ϕ along the upper and lower edges of the element respectively, A is the element area, and t_2 and t_1 are the lengths of time that the lower and upper edges of the element have been submerged.

Equation (23) is of the same form as the central difference expression used in evaluating $\frac{\partial \phi}{\partial t}$ (equ. (19)). If the pressure on the rectangular element of Figure 6 is being evaluated at step n , equations (19) and (23) become identical if the step size is chosen such that at step $n-1$ and $n+1$ the element centroid lies at the top and bottom edges of the element in step n respectively. Hence the step size should be chosen so that each element is completely submerged in two steps or

$$\Delta h = (y_2^1 - y_1^1) \cos \theta / 2$$

The preceeding analysis is not strictly applicable to three-dimensional bodies entering with variable velocity and orientation and composed quadrilateral elements with edges not necessarily parallel to the water surface. However, it is taken as a guide and Δh is picked to insure that the average element is submerged in two steps. Thus,

$$\Delta h \sim \ell \cos \theta'/2 \quad (24)$$

where ℓ is the element characteristic length and θ' is the typical element orientation angle with respect to the vertical. This criteria is easily applied on flat plates or cones. Spheres and other bodies with curvature in the axial direction are more difficult to deal with. The above is satisfied only approximately with elements perpendicular to the direction of motion being most heavily weighted. In practice, it is these elements which experience the largest pressures and hence are most crucial to the problem solution. On bodies with curvature in the axial direction the size of the elements is increased as their orientation approaches the direction of motion.

The effect of varying grid size and hence Δh on $C_{D\infty}$ and C_p is illustrated in Figures 9 and 10 respectively. On flat surfaces an accurate solution is obtained with only a small number of elements. The principal effect of increasing the number of elements is to reduce the peak calculated pressure. Since these peak pressures act over small areas the drag coefficient is relatively insensitive to increases in the number of elements. More complex shapes naturally require the use of a larger number of elements.

Describing the Entry Body with Quadrilateral Elements

In setting up a grid, best results are obtained if the afterbody is neglected and only the nose of the entering body is gridded. The pressures and source strengths on afterbody elements are small. On models with well rounded shoulders exclusion of these elements decreases the required computational effort without strongly effecting the solution. On models with sharp edges such as disk cylinders, inclusion of the afterbody elements imposes the requirement that the flow make a sharp turn about the edge of the face. This requirement is physically unrealistic since the flow will separate at the face edge. Use of afterbody elements in this case increases the flow velocity on elements near the edge which in turn decreases the calculated pressures. This is illustrated in Figures 11 and 12 which give the calculated drag for the oblique entry of a disk cylinder with and without afterbody element respectively. Results obtained in Figure 12 without the use of afterbody elements are in much closer agreement with experimental results and required a smaller amount of computational effort.

Cavity Modeling Using No Load Elements

At time following peak impact loading the existence of the flow separation region or cavity about the afterbody of entry models may have a significant effect on the model surface pressures and positive steps must be taken to model it.

Accordingly, no load elements have been introduced into the computations. These elements are placed on the water-cavity interface and their purpose is to force the flow to attain the correct streamlines in this vicinity. Loads on these elements are not included in the drag and lift totals for the entry body.

No load elements are placed on a surface extending from the position on the model where separation occurs to the effective planar surface. The actual location of each element is adjusted in successive runs until the pressures on it is at a desired level ($C_p = 0$ for a vented cavity). Typical results for a disk cylinder are shown in Figure 13 assuming a vented cavity. In this case the cavity was modeled using a single ring of elements extending from the edge of the face to the effective planar surface. Although the procedure for locating the no loads elements is not automated and therefore somewhat tedious, the results do account for much of the difference between experiment and theory. Fortunately, it is generally not necessary to include the cavity at times prior to the peak load.

Correcting Pressure on Modified Elements

During the vertical entry of axisymmetric bodies it is appropriate to apply a correction to the pressures calculated on modified elements. Under these conditions the body is gridded with elements having a pair of sides parallel to the water surface. Following the step size rule of equation (24) elements are submerged in exactly two steps. On odd numbered steps the elements adjacent to the water surface are all modified while in even numbered ones they are not modified. Apparently, the pressure levels predicted in the odd steps are not consistent with those calculated in the even ones. This is illustrated by considering the vertical entry of a 22.5, 45 and 70 degree half-angle cones. The drag coefficients, non-dimensionalized by the local surface diameter, are given in Table 1 as a function of depth. Since this problem is conical in nature the drag should be the same at each depth. For the first few steps error may be expected since the entire cone is being modeled with only a few elements. However, results should converge to a common value. It is clear from Table 1 that the odd and even number steps are converging to different values. In order to determine the better of the two answers, calculated pressure distributions are compared to experiment for typical odd and even numbered steps in Figures 14 and 15. These pressure distributions are very similar except near the water surface. Figure 14 clearly shows that the pressure on the modified element is too large. A simple correction factor, F_c , can be determined which when multiplied by the pressure on the modified element brings the total drag calculated in even and odd steps into line with one another. The value of this correction factor has been plotted in Figure 16 as a function of depth for the three different cones under consideration.

When applying the present model to the vertical entry of axisymmetric bodies, either the drag calculated in odd numbered steps should be ignored or the correction factor F_c should be used. In the remainder of this report a value of .67 is used.

The above problem does not arise during oblique entry since the edges of the generated elements are not parallel with the water surface and the number of modified elements is fairly constant from step to step. This does not mean that such a correction is not necessary. However, there is no systematic method for choosing F_c on general bodies. Experience suggests that on slender bodies (nose length/D > 1) a value of .67 should be used and in all other oblique entry cases F_c should be set to unity.

APPLICATION OF THE CODE TO SPECIFIC EXAMPLES

The previously described computer program has been applied to the oblique entry of disk cylinders, ogives, spheres, and to the vertical entry of ogives, cusps, cones, and spheres. In this section these calculations are compared to experimental results. In assessing the validity of the water-entry model it should be kept in mind that some uncertainty exists with regard to many of the experimentally determined quantities. Also, measured quantities may not be equivalent to calculated ones. The measured pressure represents the value at a specific point on the model while the calculated result reflects the average for an element of finite size. These two quantities become synonymous on elements well below the water surface.

Vertical Entry of Axisymmetric Bodies

In this section the vertical entry of cones, cusps, spheres, and ogives is considered. The two-dimensional nature of these problems insures that a single value of C_w accurately characterizes the rate of surface wetting about the entire periphery of the model. Also, separation of flow on cones and cusps can be categorically ruled out until after the shoulder of the model has entered the water. These cases thus provide an ideal opportunity for testing the proposed predictive method.

Vertical cone entry calculations are compared to the experimental results of Baldwin^{13,14} which were taken at entry velocities of 16 to 32 ft/sec. Using a correlation developed in this work, an expression for the wetting factor can be obtained which is applicable to cones with a half angle greater than 7.5 degrees:

$$C_w = \frac{1}{[1 - .396\theta_c + .287\theta_c^2 - .124\theta_c^3]} \quad (25)$$

Here θ is the cone half angle in radians. Measured and calculated pressure coefficients on 22.5, 45, and 70 degree half-angle cones are shown in Figures 15, 17, and 18. The experimental values represent a correlation based on

¹³ Baldwin, J. L., An Experimental Investigation of Water Entry, PhD Dissertation, U. of Maryland, 1972

¹⁴ Baldwin, J. L., "Vertical Water Entry of Cones," Naval Surface Weapons Center, White Oak Laboratory, NOLTR 71-25 (1971)

conical similarity which has been corrected to reflect a constant entry velocity. Use of normalized depth as the independent variable is appropriate since the computational model also produces conically similar results. Excellent agreement is obtained between calculations and experiment. In particular, predicted pressure coefficients reflect the reversal in functional form exhibited by the data with increasing cone angle. Experimental data near the tip of the cone is not shown since Baldwin has indicated that there were an absence of measurements in the region¹⁵.

In Figure 19, the calculated drag of finite length cones are compared to Baldwin's results. Good agreement exists up to the point where the cone becomes completely submerged which coincides with the occurrence of peak drag. At later times the calculated values are too low. Improved agreement between experiment and theory would probably be obtained if the cavity were modeled.

The calculated drag on vertically entering cusps and ogives are compared to the experimental measurements of reference (16) in Figures 20 to 23. The dimensions of these bodies are given in their respective figures. Predicted values are in good agreement with experiment prior to the drag peak. To accurately determine the drag peak on the cusp models the grid was extended past the actual shoulder by one row of elements. The present calculative method anticipates the end of the cusp one step before it occurs making this procedure necessary (see Equ. (18)). At times following the point of peak drag, forces on the entry body are calculated both with and without a simulated cavity. In the cases depicted in Figures 20, 21, and 23, inclusion of the cavity brings the computed drag into close agreement with experiment. The formation of a cavity does not appear important for the ogive of Figure 22. This body is the slenderest of the four models with little surface discontinuity at the shoulder-afterbody junction.

A systematic method for determining C_w in the above four cases involves substituting the local body angle, θ_2 , into equation (25) to determine C_w as a function of time. It would seem plausible to use either the local angle on the effective planar surface or at the original surface. The validity of these two approaches can be examined for the cusp models where the peak drag can be assumed to occur as the shoulder of the model is wetted. The better of these two methods is the latter, but even it overpredicts C_w resulting in a premature wetting of the shoulder. A correction factor can be determined which

¹⁵

Baldwin, J. L. Private communication

¹⁶

Baldwin, J. L., "Vertical Water Entry of Some Ogives, Cones, and Cusps", NSWC/WOL/TR 75-20, Mar 1975

produces the actual time of shoulder wetting when multiplied by the C_w factors calculated from equation (25) using θ_0 at the original surface. The results shown in Figures 20 and 21 reflect correction factor values of .97 and .94 respectively. Correction factor with values greater than unity might be postulated for ogives since their profiles are convex instead of concave. However, this type of adjustment was not carried out and the computations for the ogive models used the values of C_w defined by equation (25). Examination of Figures 22 and 23 indicates that such a correction would have reduced the discrepancy between theory and experiment.

Calculations for the vertical entry of a sphere are compared to Nisewanger's¹⁷ experimental measurements. These tests were made at an entry velocity of 23.5 ft/sec. Pressures were measured at a number of points on the model surface and integrated to produce total drag. The response times of successive gages were used to give the following expression for the wetting factor:

$$C_w = 1.736 - .829\sqrt{t^*} \quad (26)$$

Calculated pressures are compared to measured ones in Figures 24 through 26. Only the pressure measurements made while the transducers were fully wetted are shown. The predicted stagnation pressure is over estimated at early times but in good agreement otherwise. At intermediate distances from the stagnation point the predicted pressure is below the measured one. However, far from the stagnation point, as is shown in Figure 26, the calculated pressure is again close to experiment. The predicted drag is compared to experiment in Figure 27 with best agreement being obtained at early times. The measured drag does not account for model deceleration. However, these results are in good agreement with Mosteller's¹⁸ constant velocity data.

Oblique Entry of Arbitrary Bodies

The oblique entry of arbitrary bodies constitutes a more rigorous test of the predictive method since these cases are three dimensional. Calculations are compared to experiment for cones, disk cylinders, spheres, and ogives.

¹⁷ Nisewanger, C. R., "Experimental Determination of Pressure Distribution on a Sphere During Water Entry", NAVWEPS Report 7808, Oct 1961

¹⁸ Mosteller, G. G., "Axial Deceleration at Oblique Water Entry of 2-Inch-Diameter Models with Hemisphere and Disk-Cylinder Noses", NOTS NAVORD Rept. 5424, (1957)

Predicted and measured pressure distribution on a 45 degree half-angle cone entering vertically but at an angle of attack are shown in Figure 28. The experimental data are unpublished results of J. L. Baldwin of NSWC/WOL taken on the windward and leeward ray of the cone at incidences of 10 and 20 degrees. Equation (25) was used to determine C_w . On the windward ray the cone angle was incremented by the angle of attack while on the leeward side it was decreased by this amount. As can be seen from this figure, results are generally in good agreement with measurements.

Experimental data on the oblique entry of disk cylinders can be found in the work of Norman¹⁹, Mosteller¹⁸, and Baldwin¹³, representing entry velocities of 25 to 325 ft/sec. Based on the latter two sources and data taken in the present study, a C_w value of 1.45 is selected for all entry angles. Existing information for this parameter, shown in Figure 29, contains extensive scatter and hence this choice is a rough estimate. In Figure 12, the calculated drag is compared to Baldwin's empirical correlation of experimental data. Both theory and experiment agree quite well over a wide range in entry angle. Calculated pressures are compared to Aronson's experimental data in Figure 30*.

In Figures 31 and 32 calculations are compared to Aronson's pressure measurements on a three-inch-diameter ogive cylinder entering obliquely at 100 ft/sec and an angle of 60 degrees. This body has a flat face, 1.5 inches in diameter, and rounded shoulders with radii of .75 inches. The mean measure C_w value of 1.36 is used in the computations. Experimental results indicate that pressures rise more quickly, to a higher peak and fall more rapidly on the lower portion of the model face. This is particularly evident for measurements made on the shoulder of the model. The computed results closely reflect this change in the pressure trace associated with transducer location. However, peak pressures are consistently overpredicted. Fortunately, the high peak pressures act on extremely small areas and thus have little effect on the actual load for the size elements being used. To illustrate this point, experimental and calculated loads on the computational element nearest to the center of the face are plotted in Figure 33. The experimental load is obtained by applying the data from location 1 in Figure 32. The pressure-time history of each point in the computational element is assumed described by this relation.

¹⁹ Norman, J. W., Burden, W. J., and Suter, R. A., "Deceleration at Water Entry-IV, The Effects of Velocity, Entry Angle and Pitch on a Projectile with a Flat Cylindrical Head", ARL/R5/G/HY/2/3, 1960

* A brief summary of this experimental work will soon be available from the National Technical Information Service in a report titled "Prediction of Surface Pressures During Water Impact" by Wardlaw and Aronson

In Figure 27 the calculated drag for the oblique entry of a sphere is plotted against experimentally smoothed curves given by May²⁰ which are constructed from the data of references (18), (20), (21), and (22). This information reflects entry velocities between 11 and 225 ft/sec. The wetting factor for the oblique entry of a sphere has not been extensively investigated. A value of 1.35 was selected based on White's²³ limited results. Reasonably good agreement is obtained between calculated and experimental values.

Calculated loads on a slender ogive body entering obliquely are compared in Figures 34 and 35 to the unpublished drag, normal force and pitching moment data by Baldwin. The wetting factor for this case does not appear to have been investigated experimentally. A value of 1.1 is used which corresponded to the average value obtained for the vertical entry of this body using equation (25). Best agreement between measurements and calculations occurred using the OGIVE grid option, discussed in Appendix C, which produces elements with a pair of edges parallel to the water surface. Consistent with previous discussion, the calculated loads at odd numbered steps are discarded. Analytical results are in closest agreement with experiment at the entry angle of 75 degrees as shown in Figure 35. The premature decrease in the calculated drag at $\theta = 45^\circ$ in Figure 34 can probably be attributed to the formation of a cavity along the upper surface of the ogive. The use of no load elements to model the water-cavity interface could conceivably decrease this discrepancy. Consistent with trends visible in previous examples, the underprediction of the drag initially occurs near the point where the total load on the slender ogive model peaks.

The present calculative procedure does not include the contribution to normal force and pitching from the formation of an underpressure cavity. Hence in cases where this effect is important the calculated normal force and pitching moment will not be very accurate.

²⁰Hobbs, E. V., Breakstone, H. I., and Woodson, J. B., "Oblique Entry of Spheres into Water", NBS Rept. 2788 (1951)

²¹Hydroballistics Design Handbook, BuOrd NAVORD Rept. 3533 (1955)

²²Norman, J. W., Burden, W. J., and Suter, R. A., "Deceleration at Water Entry-III, Velocity, Entry Angle, and Pitch Effects on a Projectile with a Hemisphere Head", ARL/R4/G/HY/2/3 (1959)

²³White, F. G., "Photographic Studies of Splash in Vertical and Oblique Water Entry of Spheres", NAVORD Report 1228, 1950

SUMMARY AND CONCLUSIONS

This technical report outlines a systematic method for calculating surface pressures, forces and moments on arbitrary bodies during the early phases of water entry. A potential flow model is assumed and the free surface is approximated by an effective planar surface empirically located at the splash height. The computational techniques of Smith and Hess are used to solve the the potential problem. This requires that the surface of the body be described by planar quadrilateral elements. Using Bernoulli's equation the average pressure is calculated on each element and then integrated to produce total forces and moments on the entry body. Through the use of no load elements it is possible to model the cavity which form about the entry body, but this is generally not necessary.

The described method of calculation has been applied to a number of different cases in which experimental data is available. For vertical entry this includes cones with and without angle of attack, ogives, cusps, and spheres. The oblique entry case has been studied for disk cylinders, spheres, blunt and slender ogives covering entry angles between 30 and 90 degrees. The predicted pressure traces accurately duplicate experimental results, reflecting not only overall body geometry but also location on the body surface. The calculated loads are in good agreement with experimental values, particularly prior to the point of peak loading. At later times no load elements must be used to model the water-cavity interface.

Although the current predictive method is a viable engineering tool, some shortcomings are evident. Most notably, pressures on elements adjacent to the water surface are often overpredicted. This is not surprising considering the singularity which exists at the water surface in the current formulation. An empirical correlation scheme based on an experimental data correlation (e.g., reference (24)) might offer substantial improvement. Finally, it is clear from the studied examples that positive steps must be taken to model the cavity after the point of peak load. Provisions should be made for automating this procedure.

²⁴ Baldwin, J. L., and Steves, H. K., "Vertical Water Entry on Spheres", NSWC/WOL/TR 75-49, May 1975

**TABLE 1 CALCULATE CONE DRAG AS A FUNCTION OF STEP NO.
AT ODD NUMBER STEPS ELEMENT ADJACENT TO THE
WATER SURFACE IS MODIFIED WHILE ON EVEN
NUMBER STEPS IT IS NOT.**

θ_0 STEP NO.	22.5°	45°	70°
1	0.565	2.178	9.218
2	0.455	1.815	7.964
3	0.430	1.744	7.902
4	0.333	1.455	6.528
5	0.396	1.811	7.376
6	0.333	1.391	6.356
7	0.373	1.543	7.186
8	0.323	1.369	6.300
9	0.382	1.511	7.042
10	0.322	1.361	6.276
11	0.354	1.483	6.925
12	0.321	1.354	6.267
13	0.349	1.463	6.850
14	0.320	1.349	6.258
15	0.346	1.432	6.790
16	0.321	1.344	—

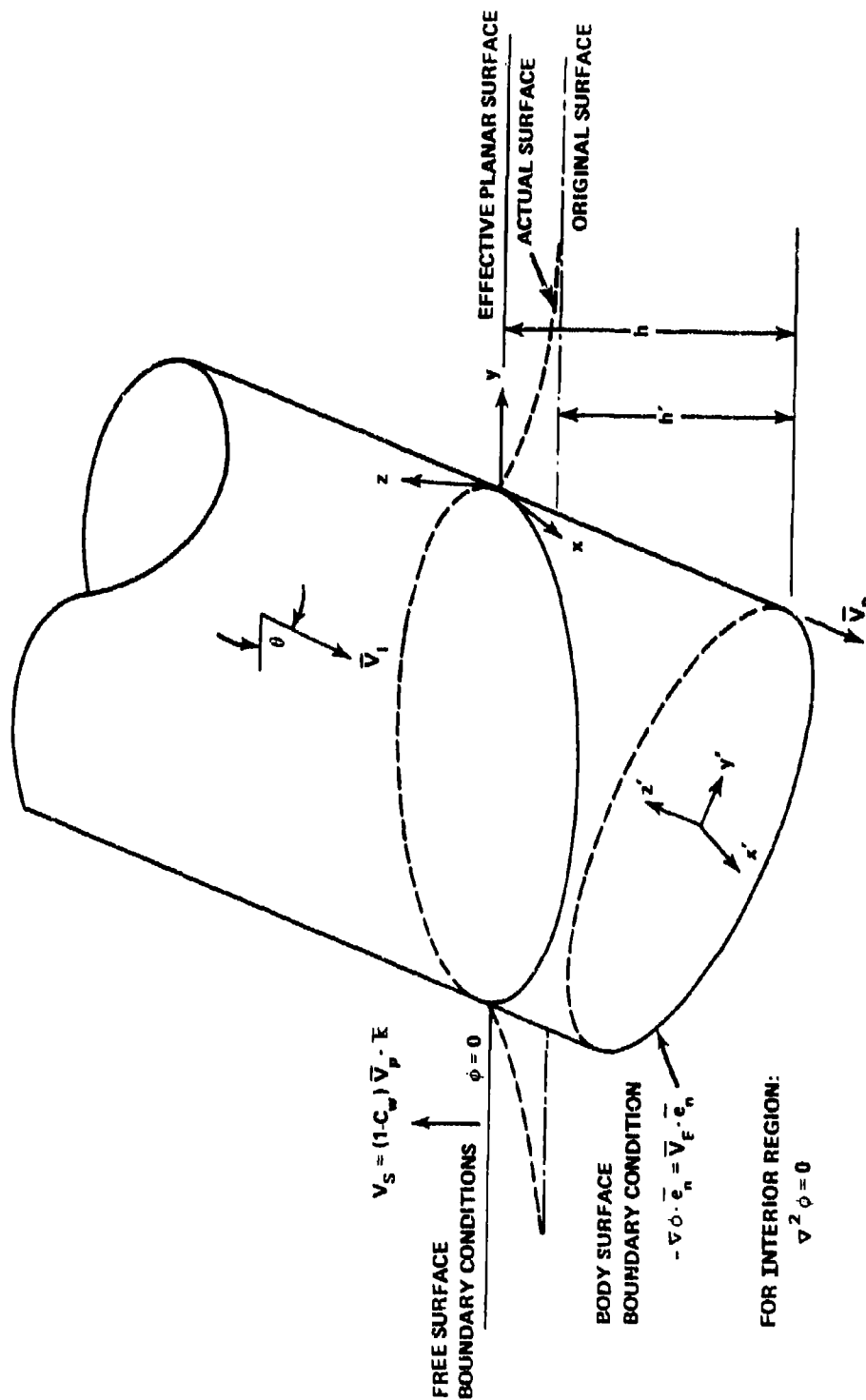


FIG. 1 PROBLEM FORMULATION

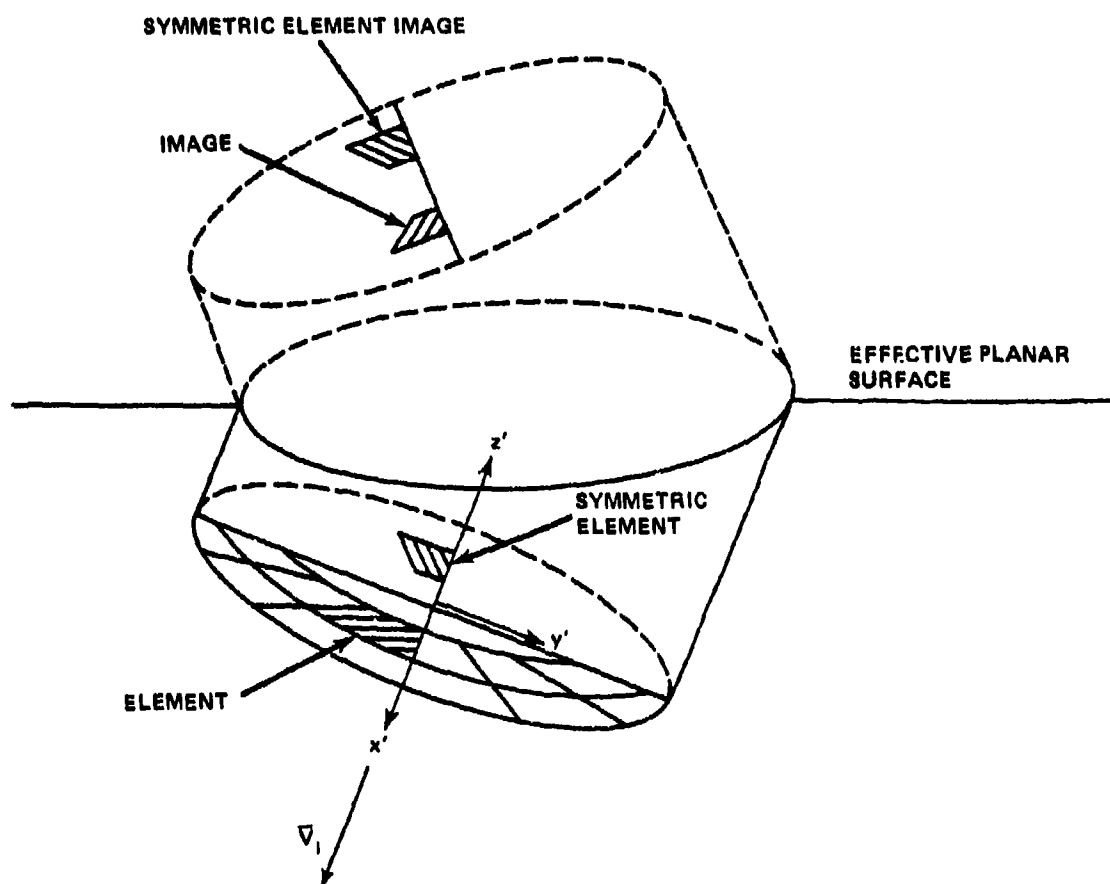


FIG. 2 ELEMENTS WITH SIMILAR SOURCE STRENGTHS. ONLY HALF OF A BODY WITH $y' - z'$ PLANE IS GRIDDED. EACH ELEMENT HAS A CORRESPONDING SYMMETRIC, IMAGE AND IMAGE SYMMETRIC ELEMENT OF THE SAME SOURCE STRENGTH MAGNITUDE.

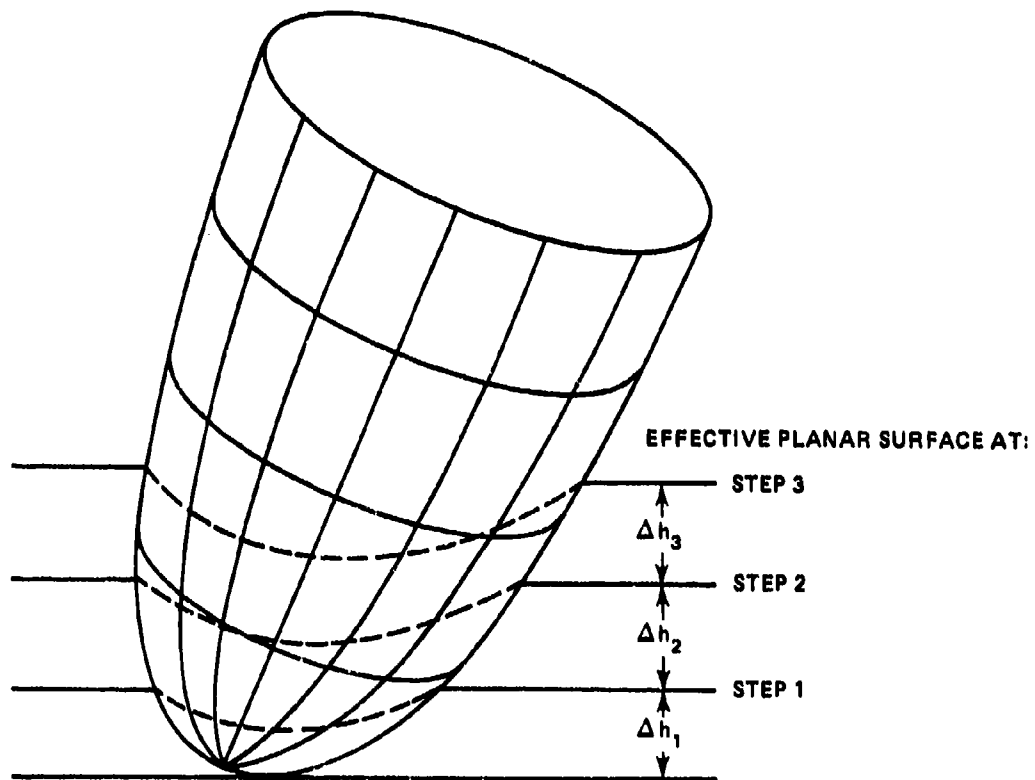


FIG. 3 COMPUTATIONAL GRID. THE MODEL SURFACE IS DIVIDED INTO PLANAR QUADRILATERAL ELEMENTS. ALSO SHOWN IS THE INTERSECTION OF THE WATER SURFACE AND THE MODEL DURING THE FIRST THREE STEPS.

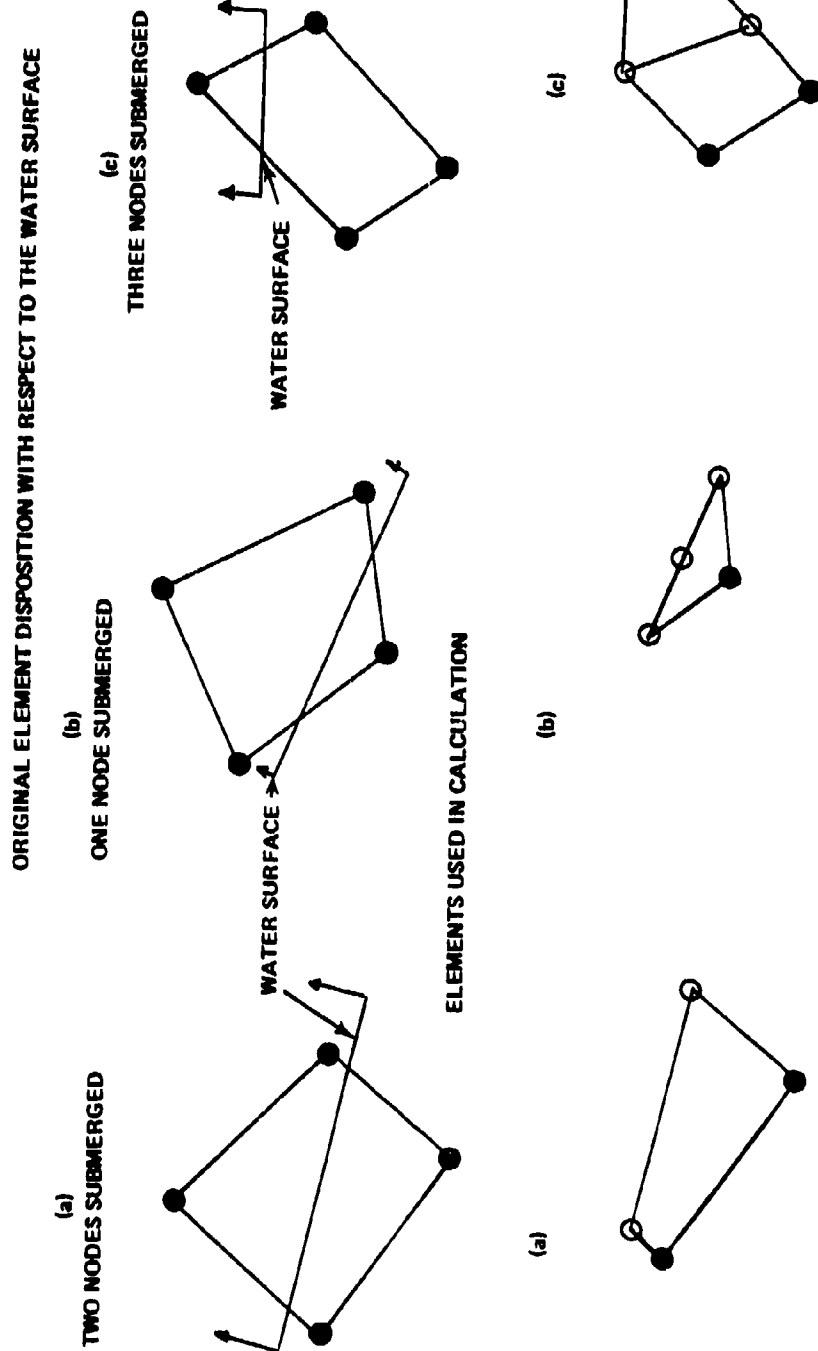


FIG. 4 ELEMENTS WHICH ARE INTERSECTED BY THE WATER SURFACE ARE REDEFINED. THE THREE POSSIBLE CASES WHICH CAN ARISE ARE DEPICTED. ○ REPRESENT ORIGINAL NODES. ● ARE THE GENERATED NODES LYING ON THE WATER SURFACE.

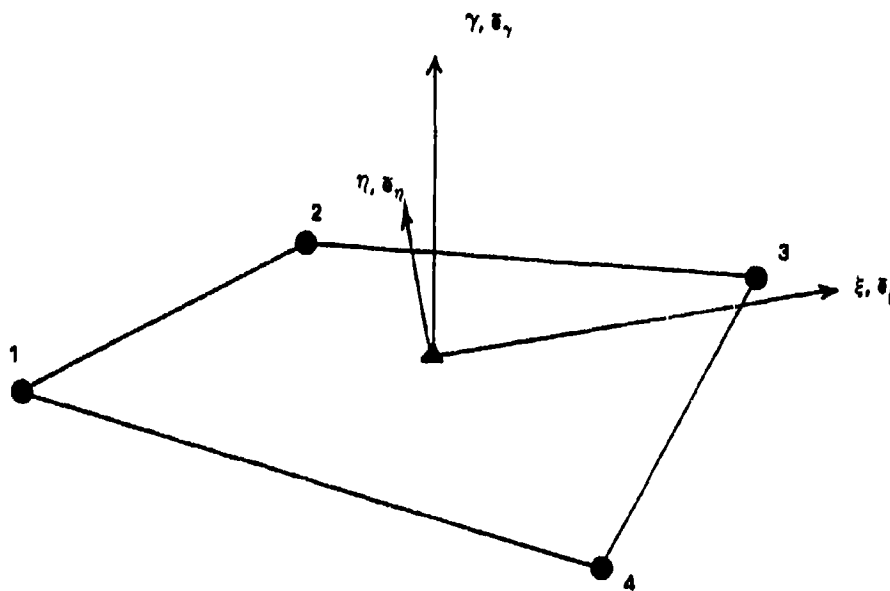


FIG. 5 THE NODES DEFINING EACH ELEMENT ARE ARRANGED IN CLOCKWISE ORDER. A ξ, η, γ COORDINATE SYSTEM IS DEFINED FOR EACH ELEMENT AND LOCATED AT THE ELEMENT CENTROIDE.

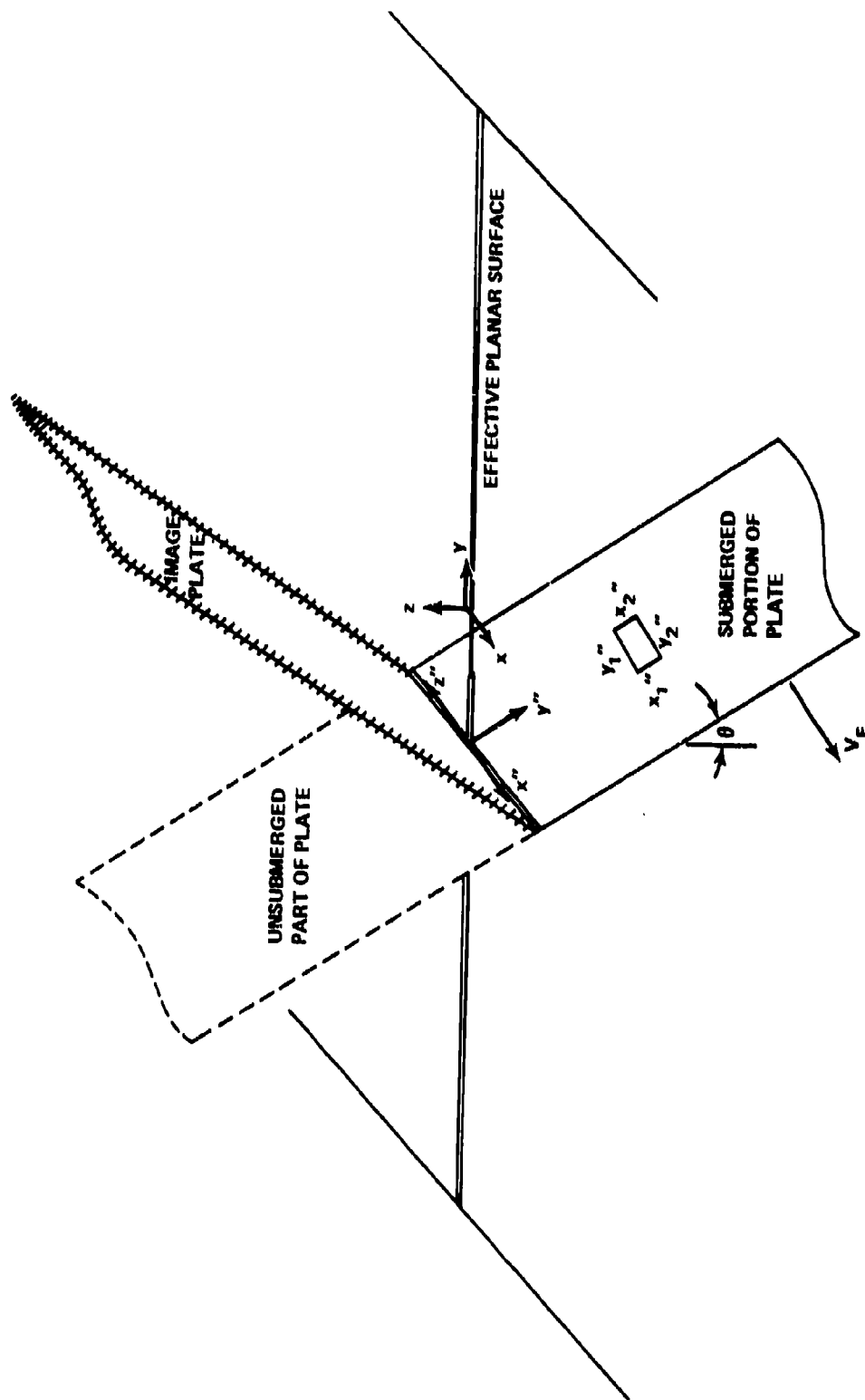
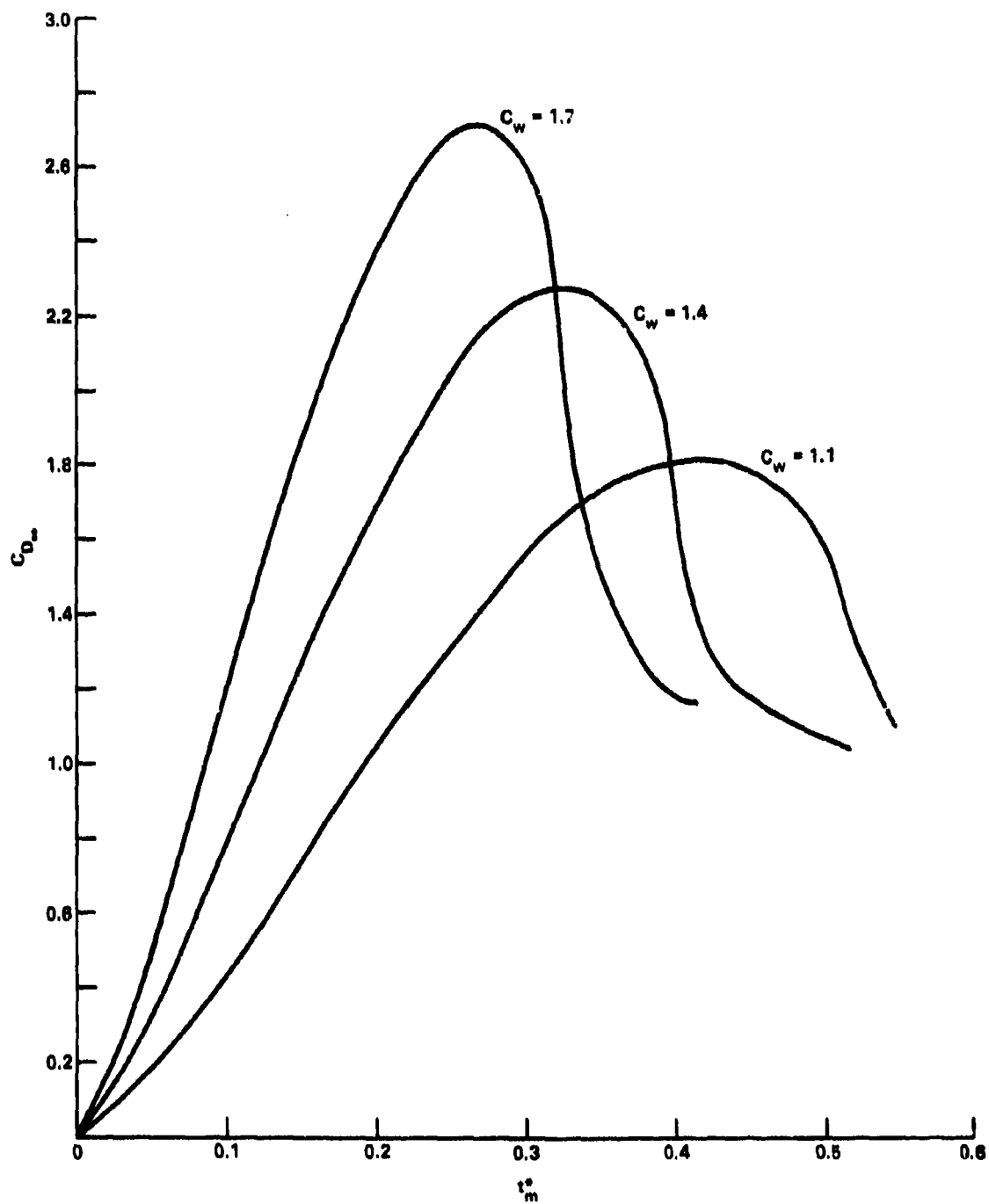


FIG. 6 PLATE OF FINITE WIDTH AND INFINITE LENGTH ENTERING THE WATER OBLIQUELY
SUBJECT TO THE ASSUMED BOUNDARY CONDITIONS.

FIG. 7 DRAG OF A DISK AT AN ENTRY ANGLE OF 60 DEGREES AS A FUNCTION OF C_w .

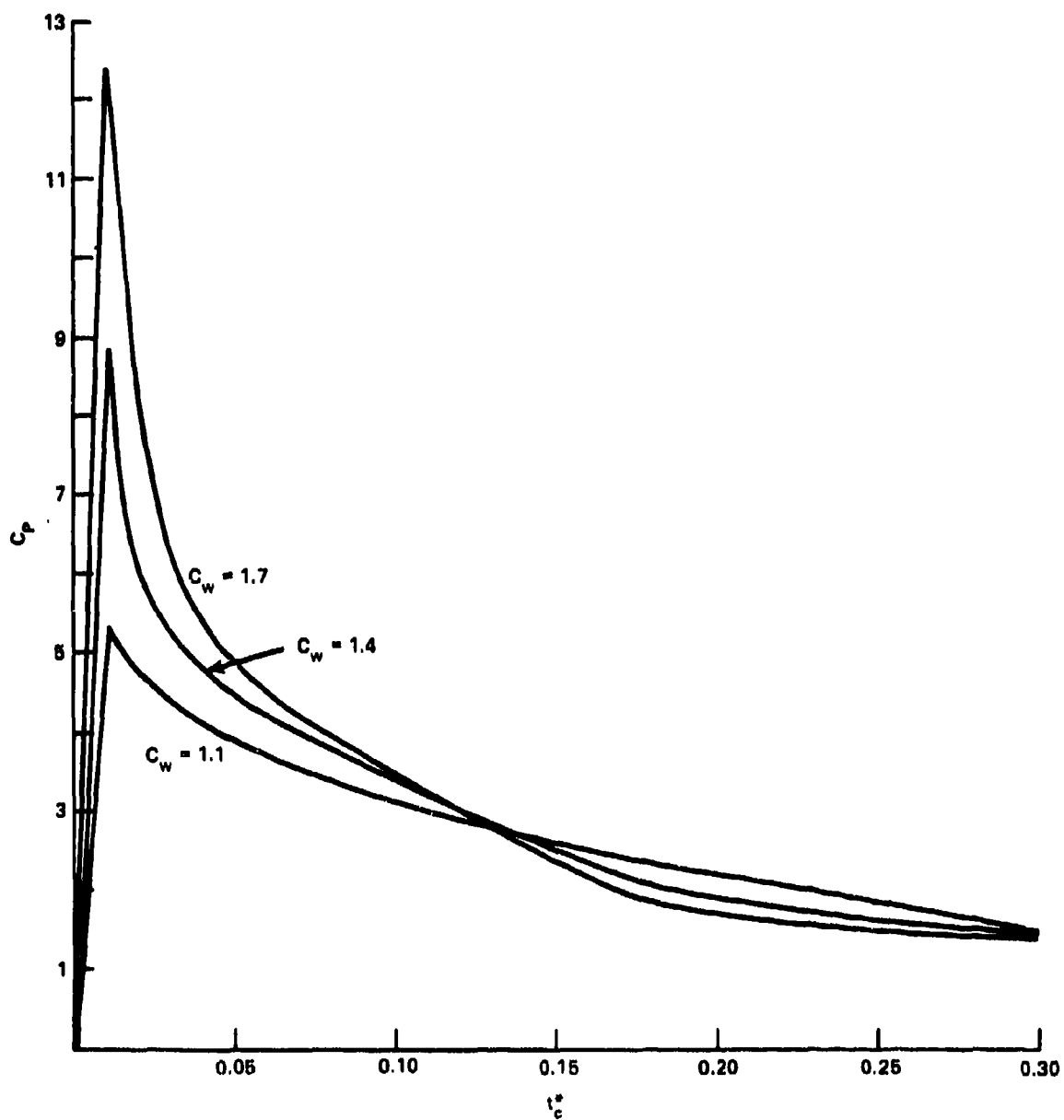


FIG. 8 PRESSURE COEFFICIENT AT THE CENTER OF A DISK CYLINDER ENTERING AT 60 DEGREES AS A FUNCTION OF C_w .

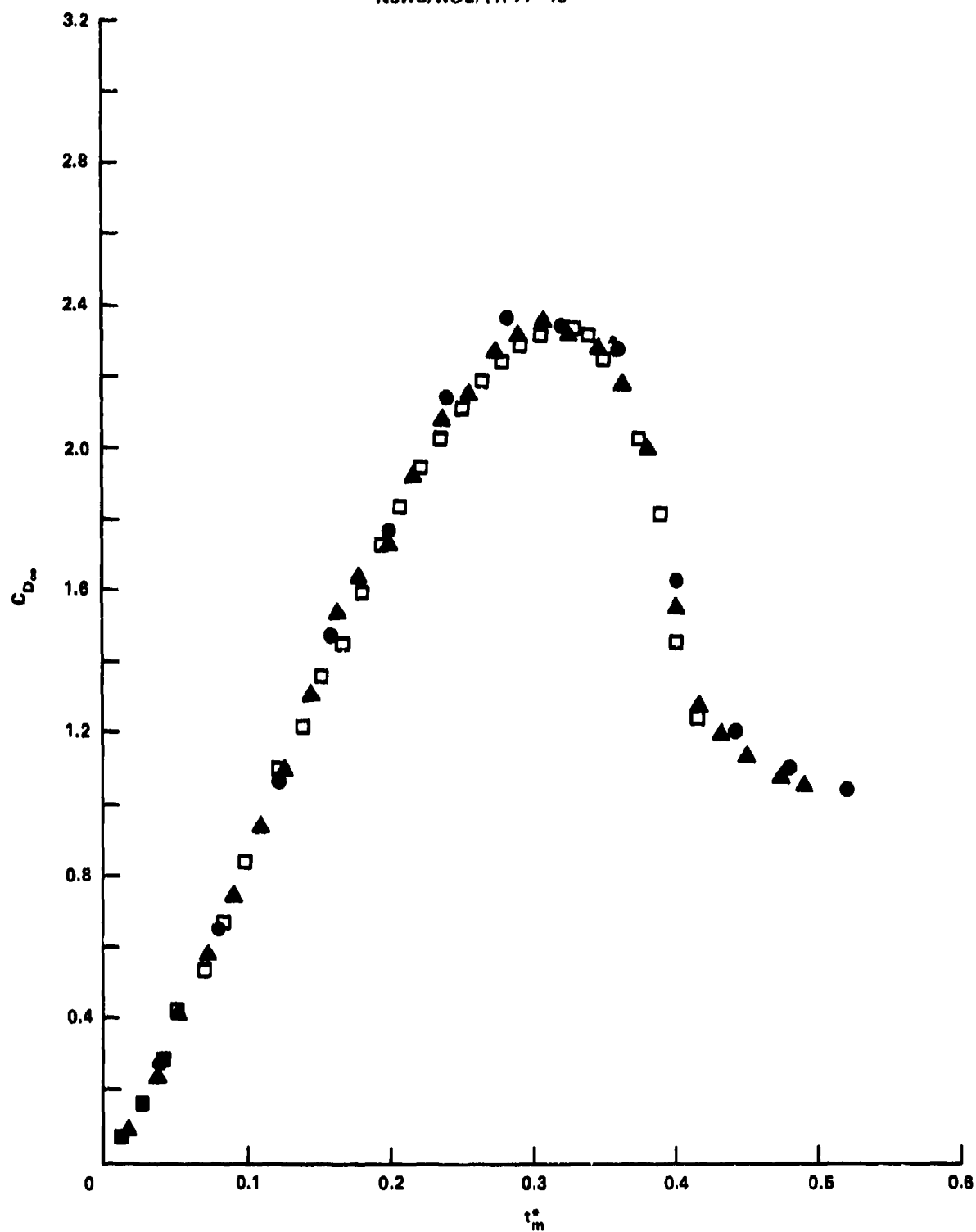


FIG. 9 THE EFFECT ON CALCULATED DRAG OF VARYING THE GRID SIZE. THE ENTRY BODY IS A DISK CYLINDER AT $\theta = 60$ AND $C_w = 1.45$. ● 12 ELEMENT GRID ▲ 51 ELEMENT GRID □ 92 ELEMENT GRID.

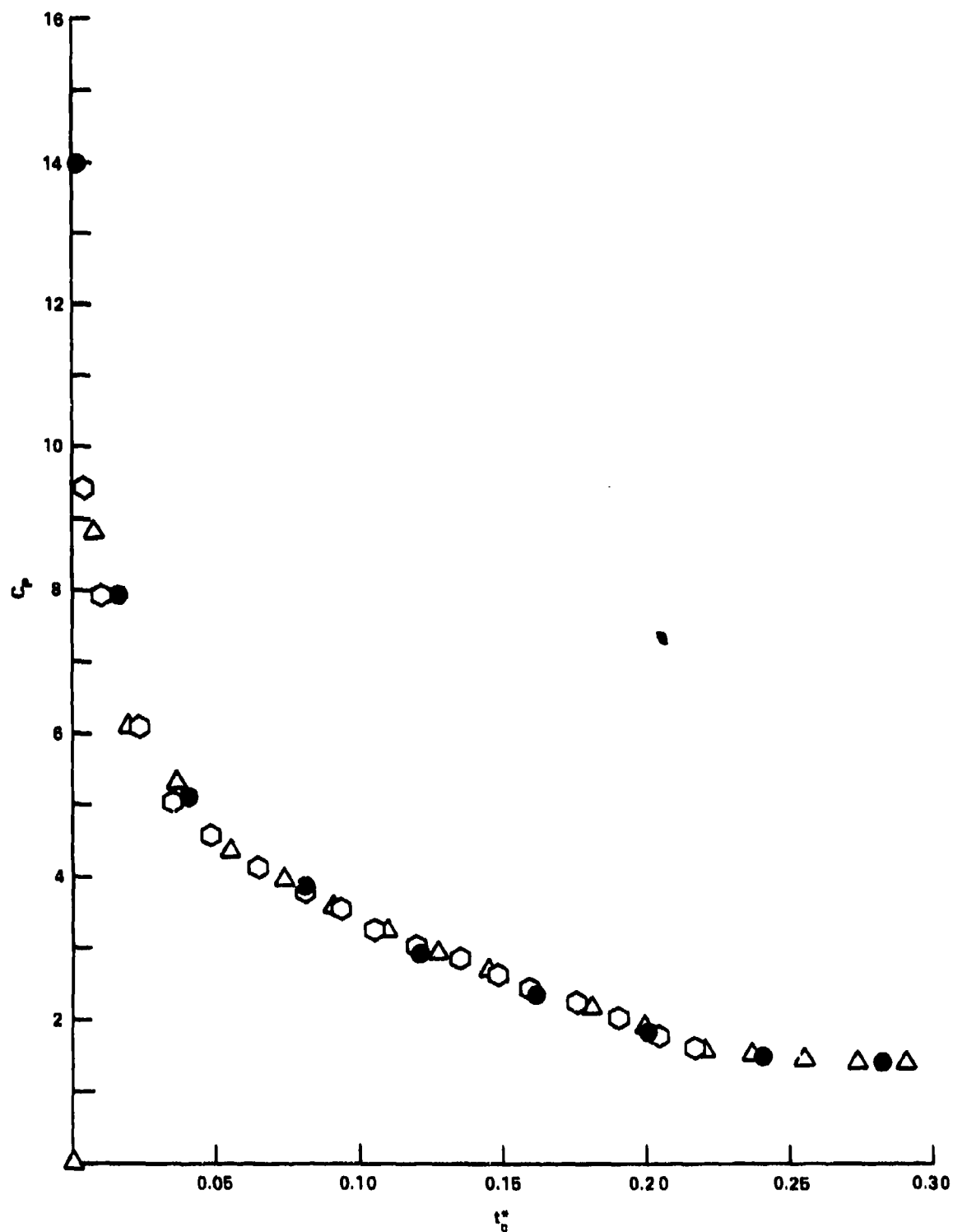


FIG. 10 THE EFFECT ON THE PRESSURE COEFFICIENT AT THE CENTER OF A DISK ENTERING OBLIQUELY AT $\theta = 60$ OF VARIOUS GRID SIZES. ● 12 ELEMENT GRID △ 51 ELEMENT GRID ○ 92 ELEMENT GRID

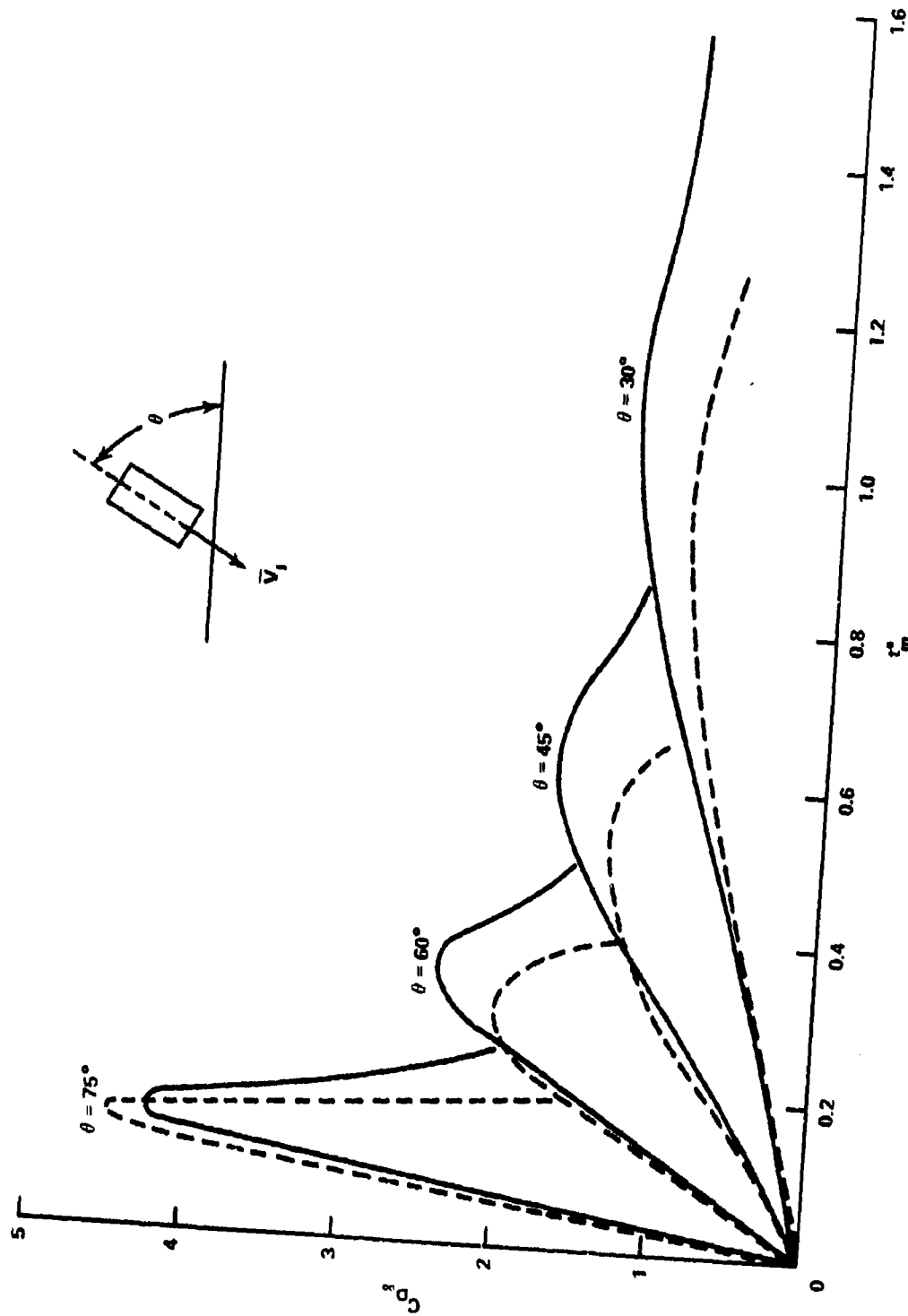


FIG. 11 PREDICTED AND MEASURED DRAG ON A DISK CYLINDER AT VARIOUS ENTRY ANGLES.
 $C_W = 1.45$ — EXPERIMENTAL DATA BY BALDWIN¹³ - - CALCULATED RESULTS WITH
 MODEL

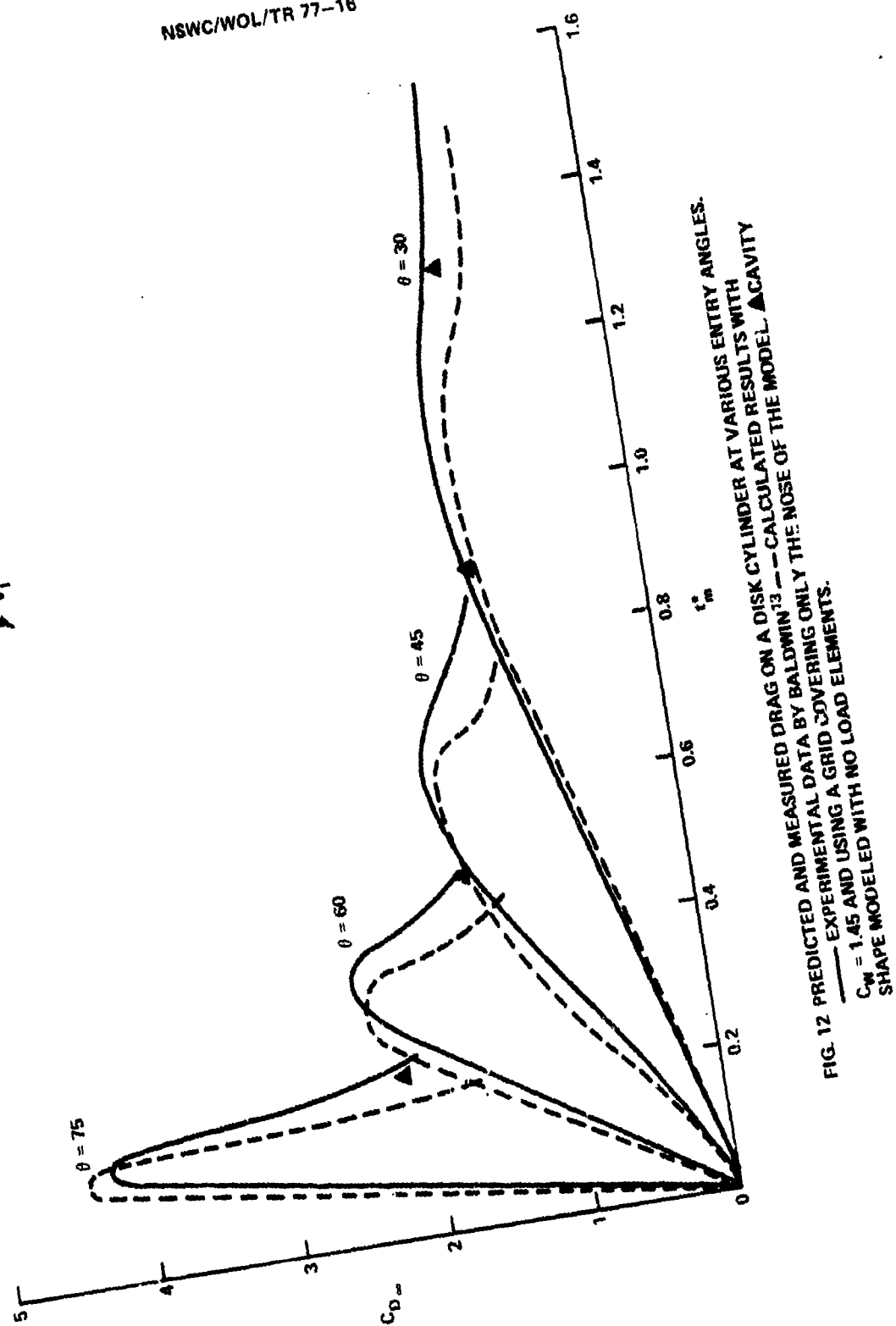
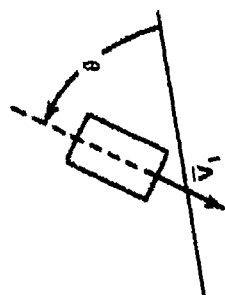


FIG. 12 PREDICTED AND MEASURED DRAG ON A DISK CYLINDER AT VARIOUS ENTRY ANGLES.
 $C_W = 1.45$ AND USING A GRID COVERING ONLY THE NOSE OF THE MODEL. \triangle CAVITY
 SHAPE MODELED WITH NO LOAD ELEMENTS.

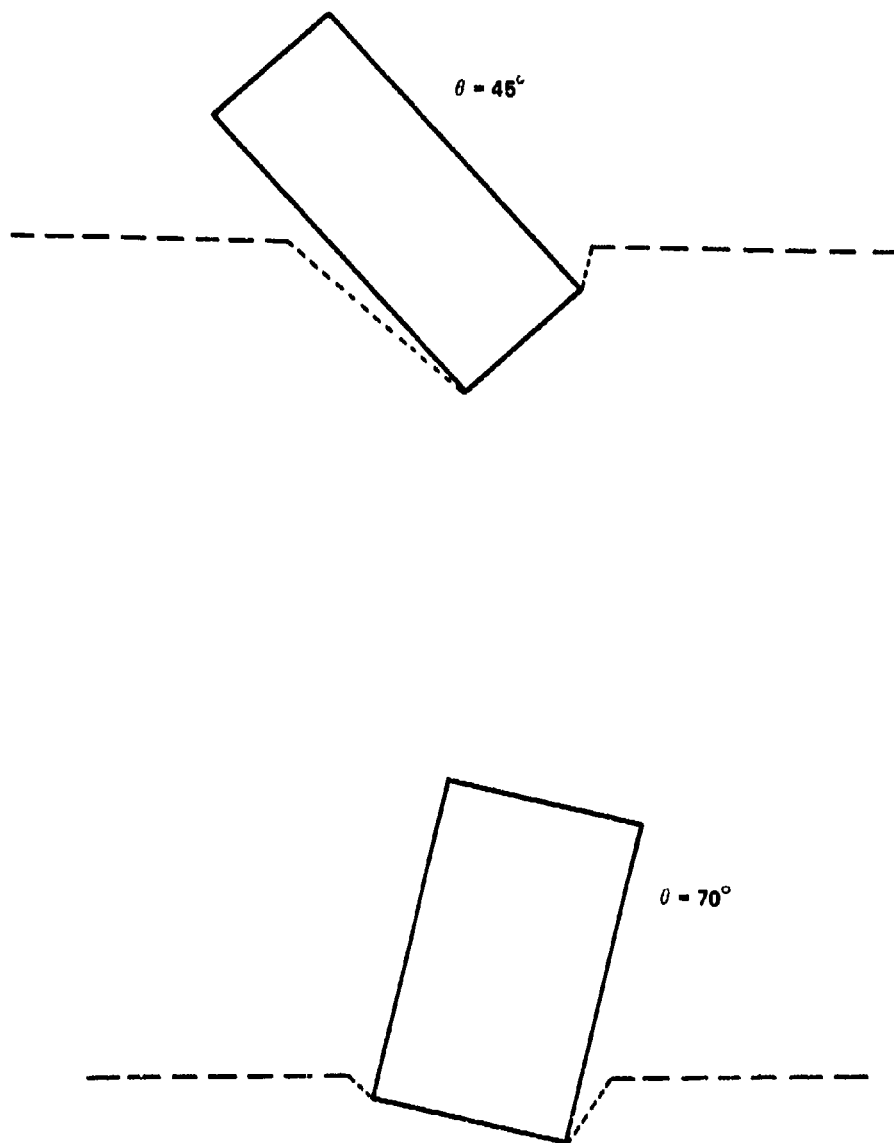


FIG. 13 PROFILE OF THE CAVITY ABOUT A DISK CYLINDER AT SEVERAL ENTRY ANGLES
CALCULATED USING NO LOAD ELEMENTS. — — EFFECTIVE PLANAR SURFACE
--- WATER-CAVITY INTERFACE.

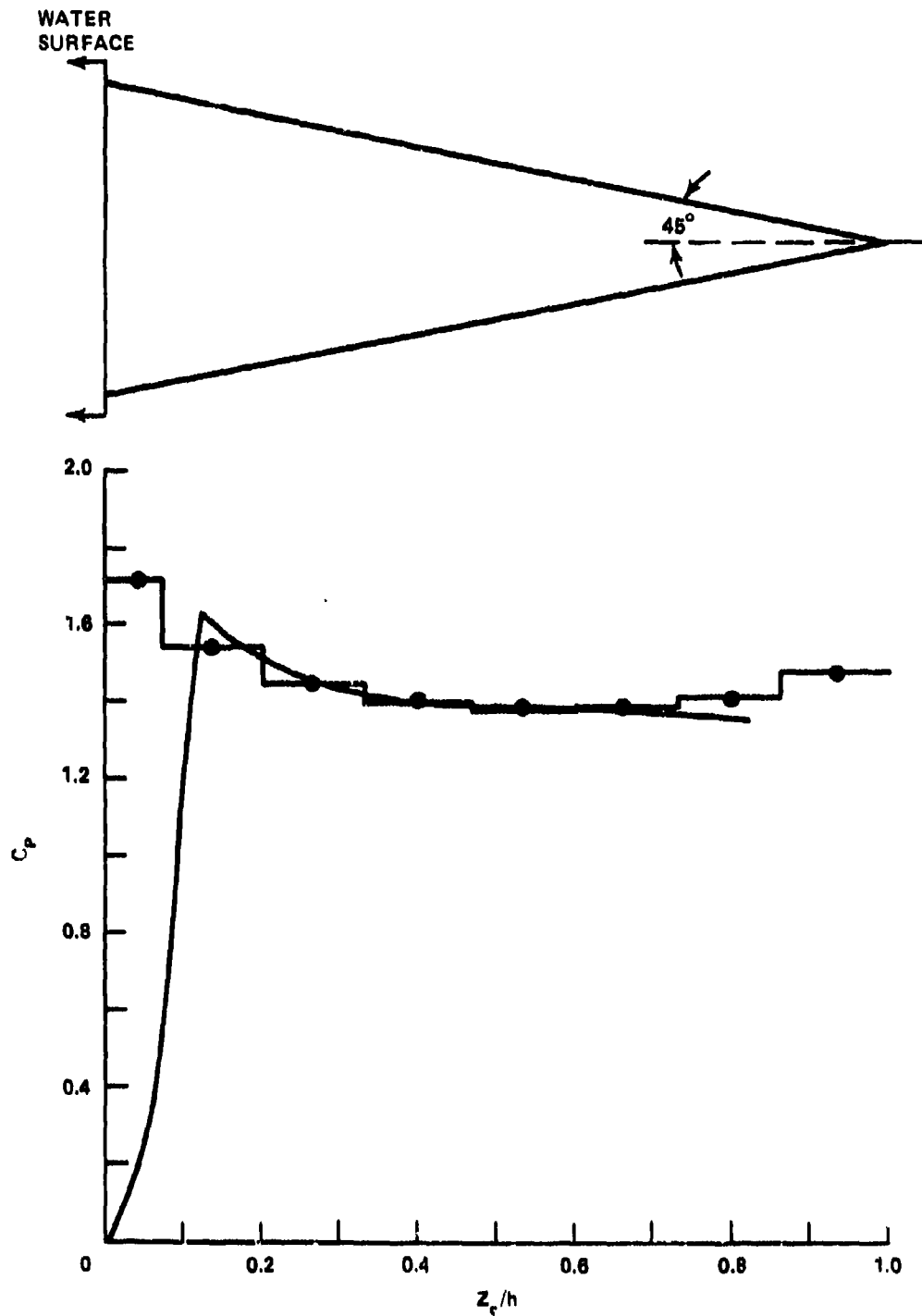


FIG. 14 PRESSURE DISTRIBUTION ON A 45 DEGREE HALF-ANGLE CONE ENTERING VERTICALLY. THE SHADED CIRCLES REPRESENT THE CALCULATED VALUES AT ELEMENT CENTRIDS WHILE THE HORIZONTAL LINES INDICATE THE EXTENT OF EACH ELEMENT. THE ELEMENT ADJACENT TO THE WATER SURFACE IS MODIFIED. $C_w = 1.45$. THE SOLID CURVE IS EXPERIMENTAL DATA BY BALDWIN¹³.

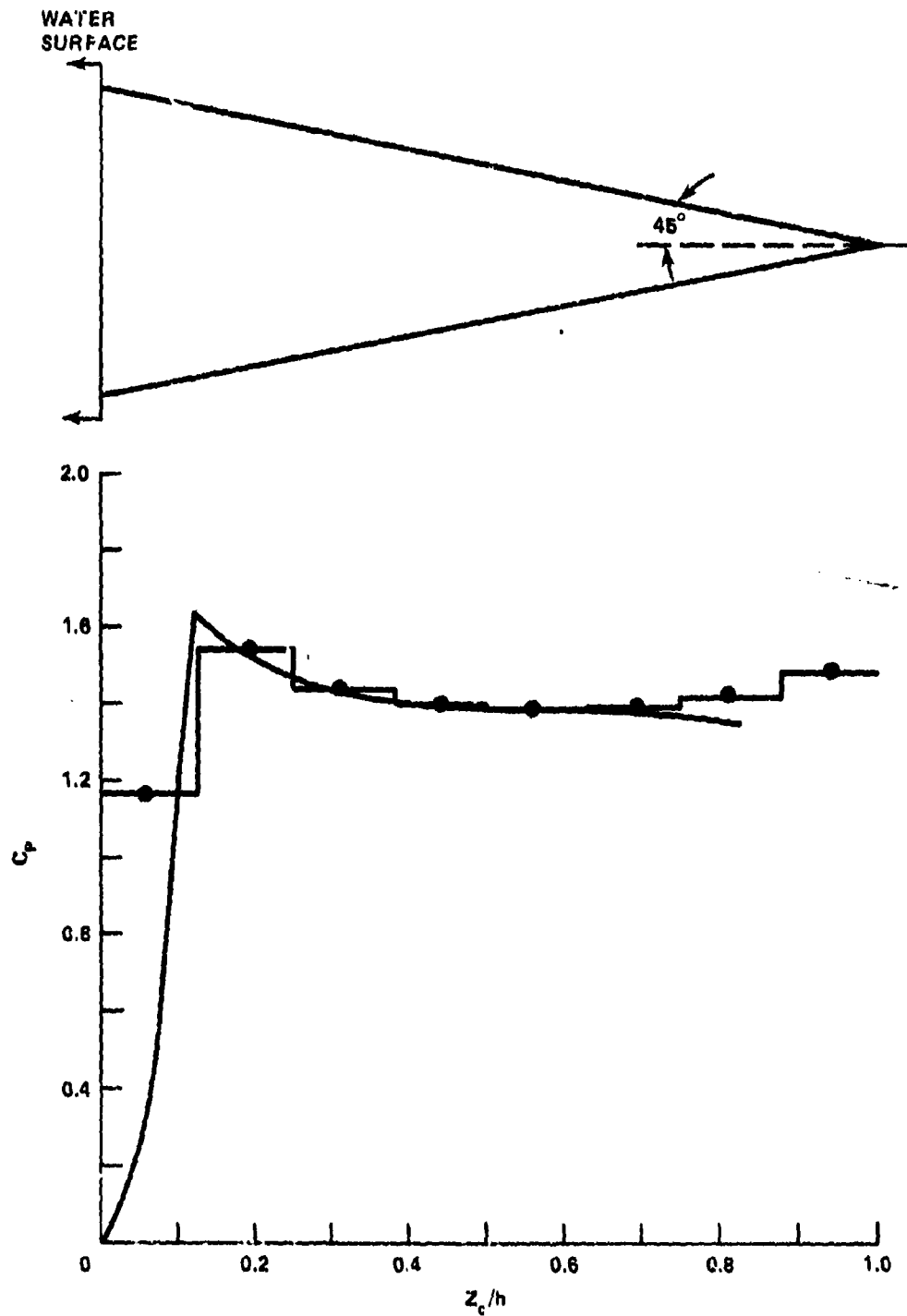


FIG. 15 PRESSURE DISTRIBUTION ON A 45 DEGREE HALF ANGLE CONE ENTERING VERTICALLY. THE SHADED CIRCLES REPRESENT THE CALCULATED VALUES AT ELEMENT CENTROIDS WHILE THE HORIZONTAL LINES INDICATE THE EXTEND OF EACH ELEMENT. THE SOLID CURVE IS EXPERIMENTAL DATA BY BALDWIN¹³. THE ELEMENT ADJACENT TO THE WATER SURFACE IS NOT MODIFIED. $C_w = 1.45$.

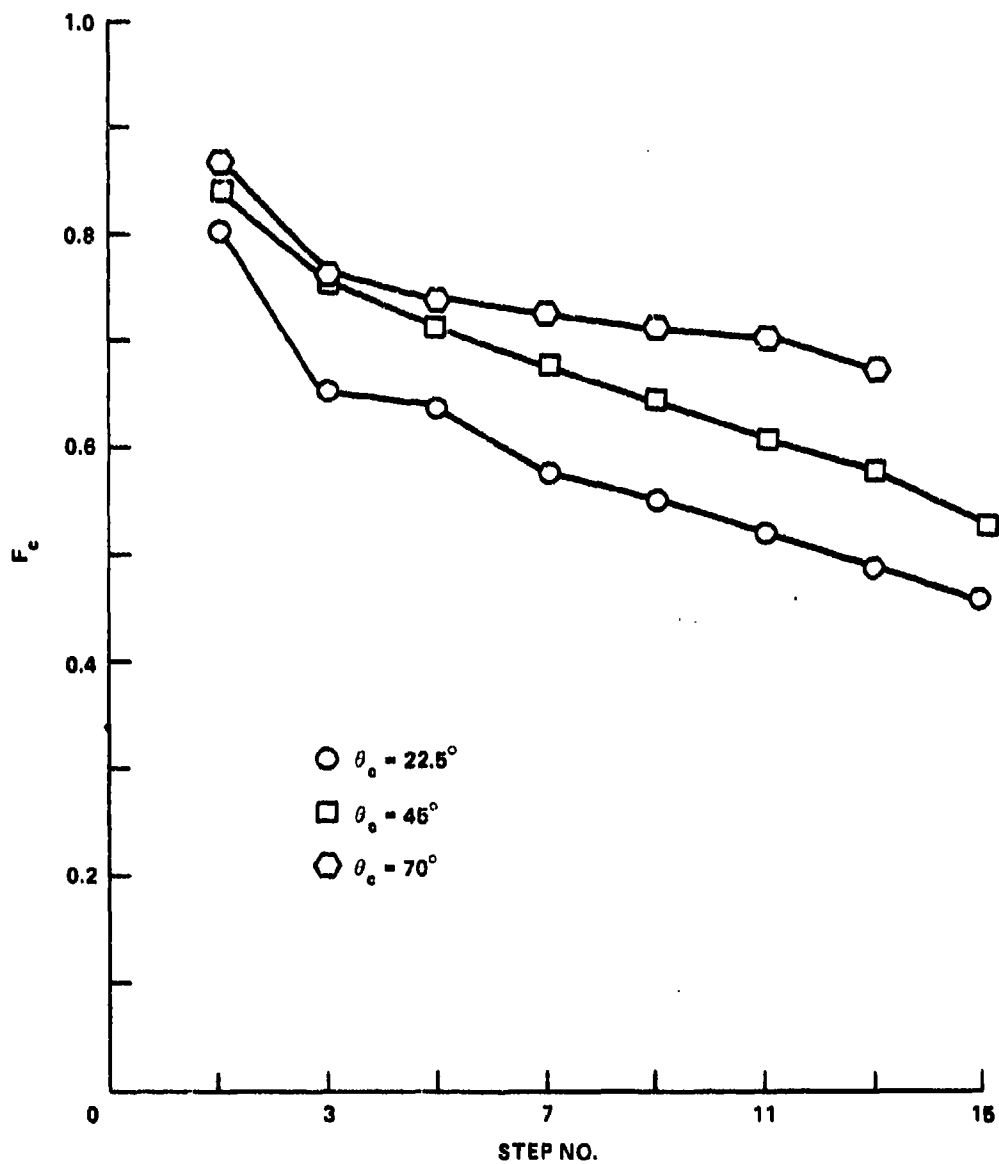


FIG. 16 MODIFIED ELEMENT CORRECTION FACTOR AS A FUNCTION OF STEP NUMBER.

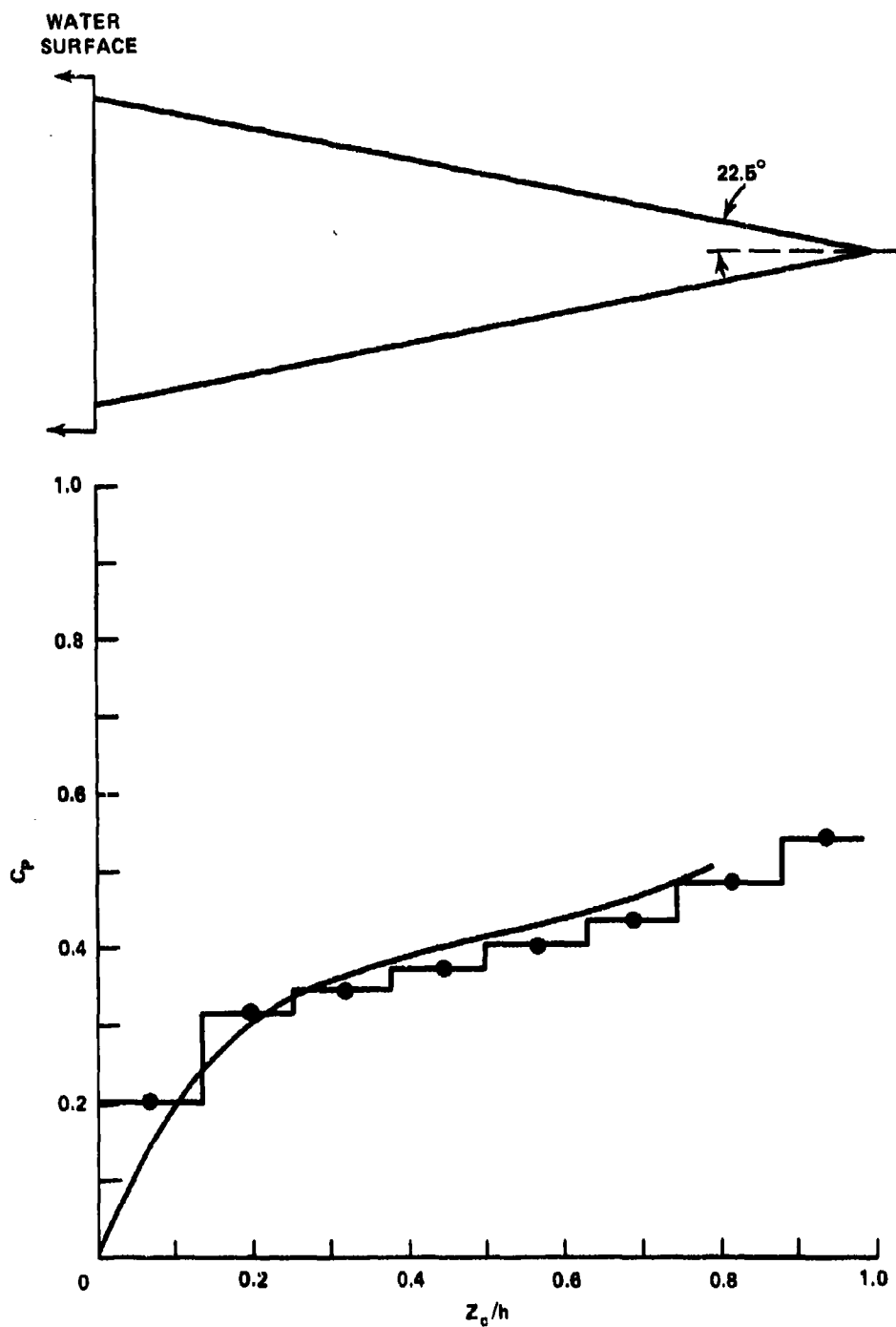


FIG. 17 PRESSURE DISTRIBUTION ON A 22.5 DEGREE HALF-ANGLE CONE ENTERING VERTICALLY. THE SHADED CIRCLES REPRESENT THE CALCULATED VALUE AT EACH ELEMENT CENTROID. WHILE THE HORIZONTAL LINES INDICATE THE EXTENT OF EACH ELEMENT. THE SOLID CURVE IS EXPERIMENTAL DATA BY BALDWIN¹³, $C_w = 1.14$.

WATER SURFACE

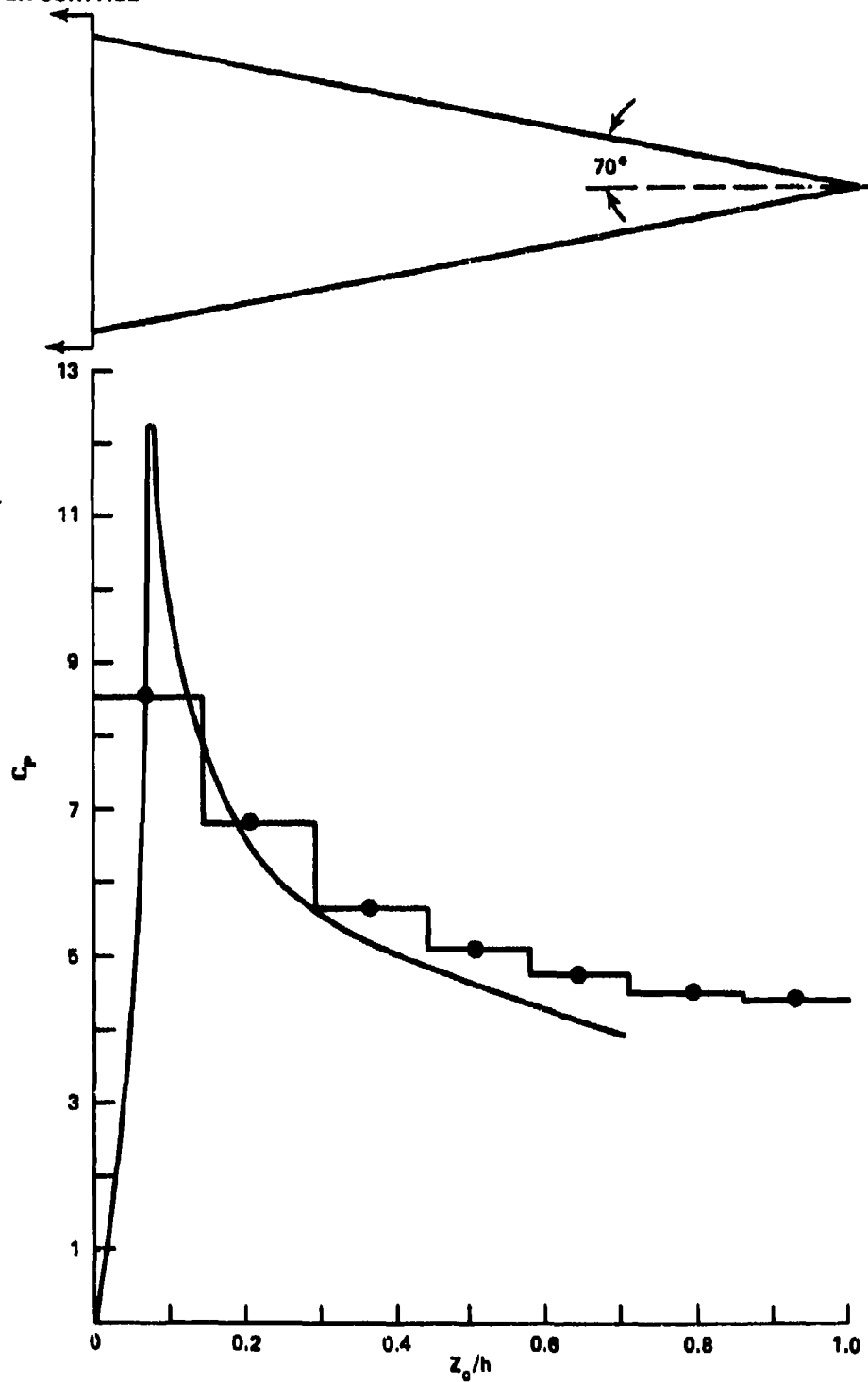


FIG. 18 PRESSURE DISTRIBUTION ON A 70 DEGREE HALF-ANGLE CONE ENTERING VERTICALLY. THE SHADED CIRCLES REPRESENT THE CALCULATED VALUE AT EACH ELEMENT CENTROID WHILE THE HORIZONTAL LINES INDICATE THE EXTENT OF EACH ELEMENT. THE SOLID CURVE IS EXPERIMENTAL DATA BY BALDWIN¹³, $C_w = 1.39$.

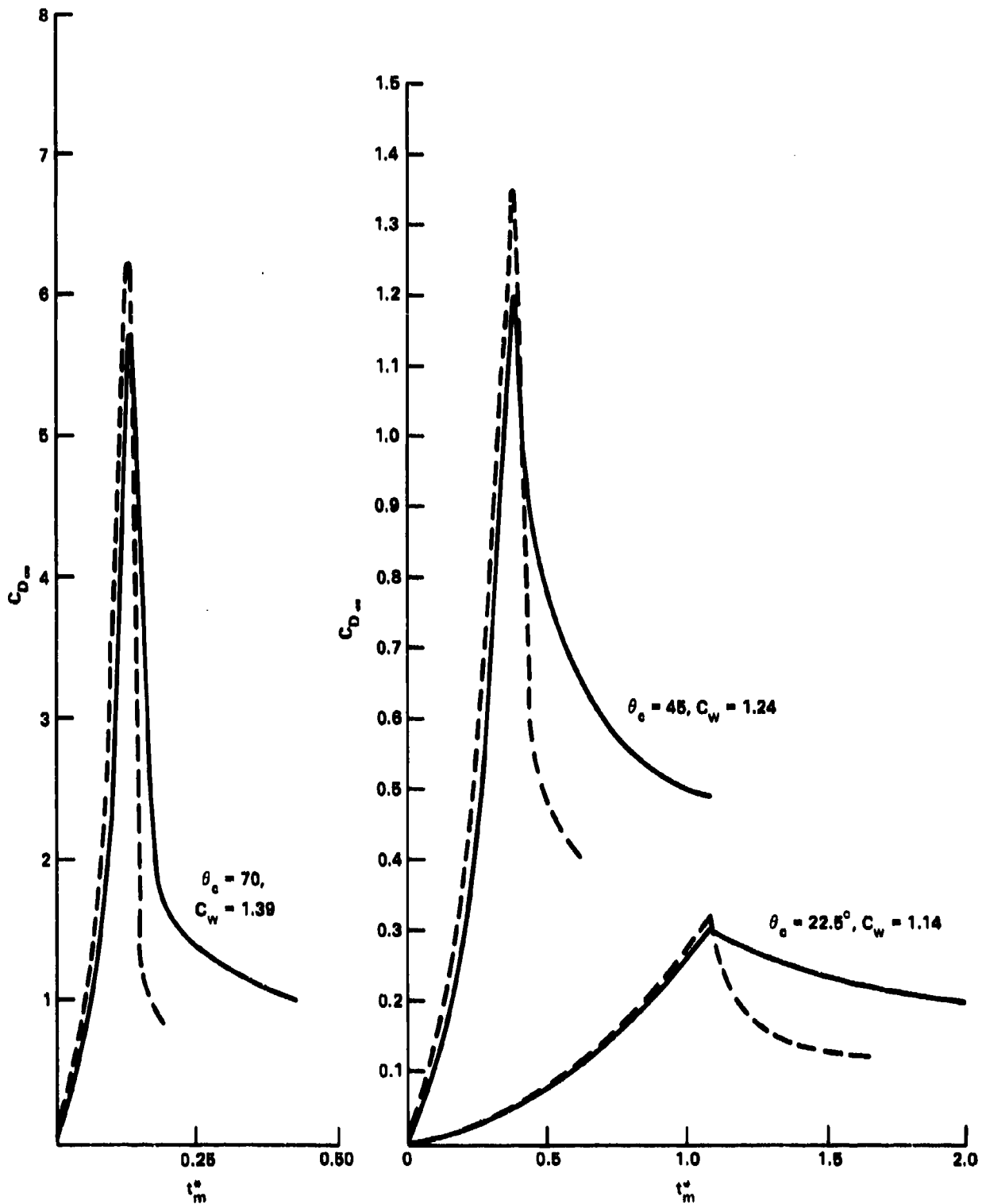


FIG. 19 CALCULATED AND MEASURED DRAG ON VERTICALLY ENTERING CONES.
 — MEASURED BY BALDWIN¹⁴ --- CALCULATED.

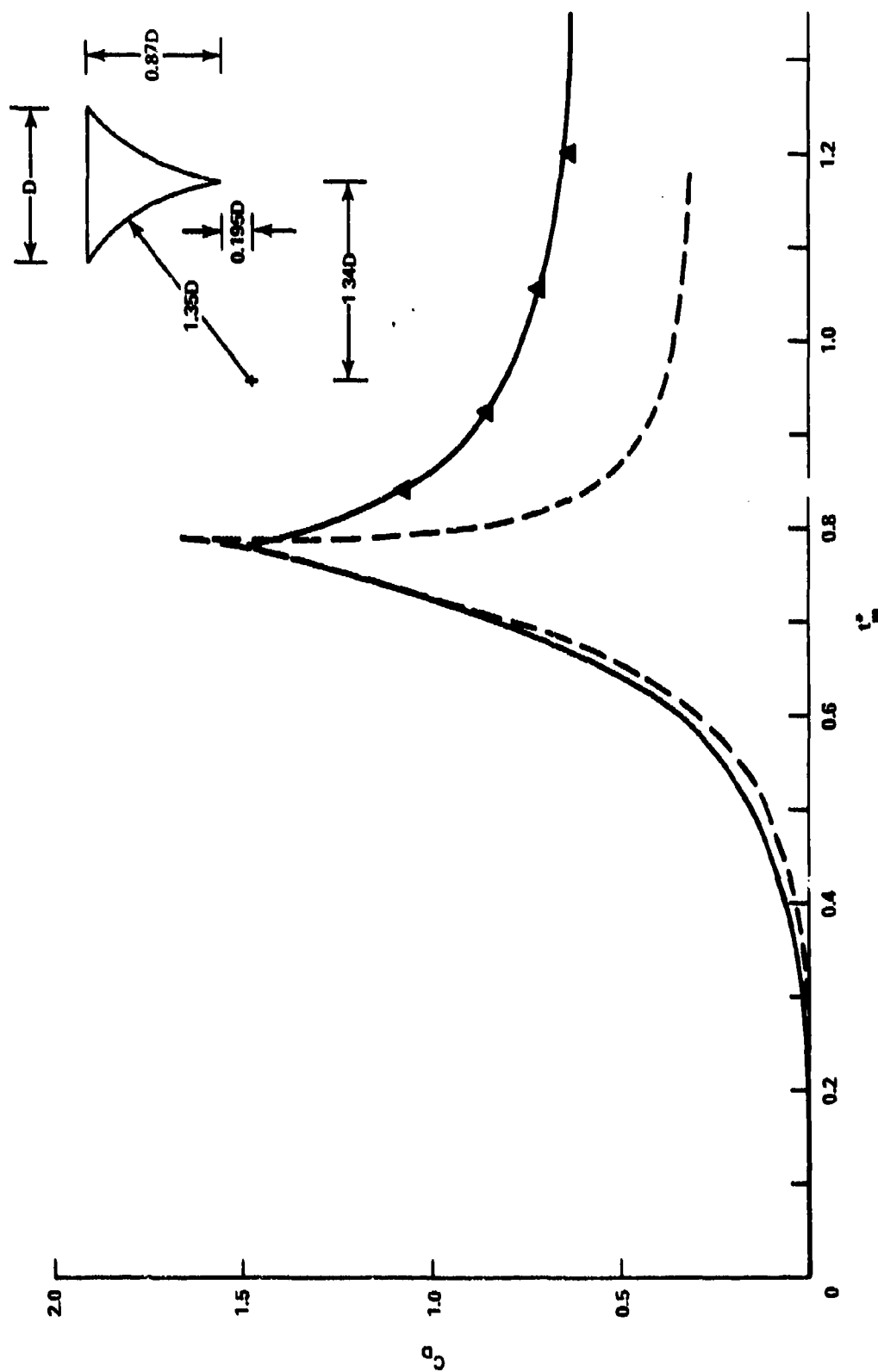


FIG. 20 CALCULATED AND MEASURED DRAG ON A VERTICALLY ENTERING CUSP. --- CALCULATED. — MEASURED¹⁶ ▲ CALCULATED WITH A CAVITY SIMULATED BY NO LOAD ELEMENTS.

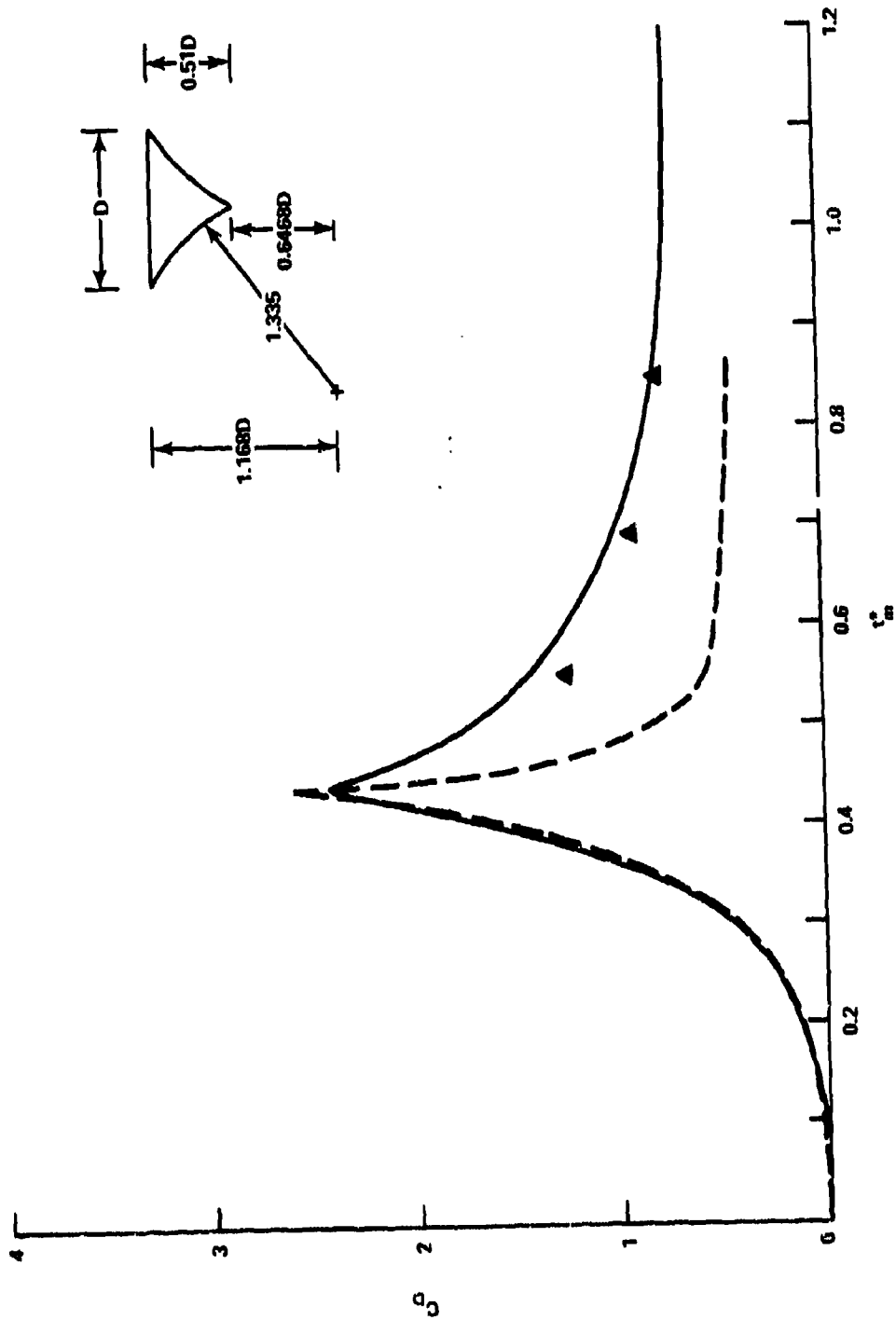


FIG. 21 CALCULATED AND MEASURED DRAG ON A VERTICALLY ENTERING CUSP. --- CALCULATED
 — MEASURED \blacktriangle CALCULATED WITH A CAVITY SIMULATED BY NO LOAD ELEMENTS.

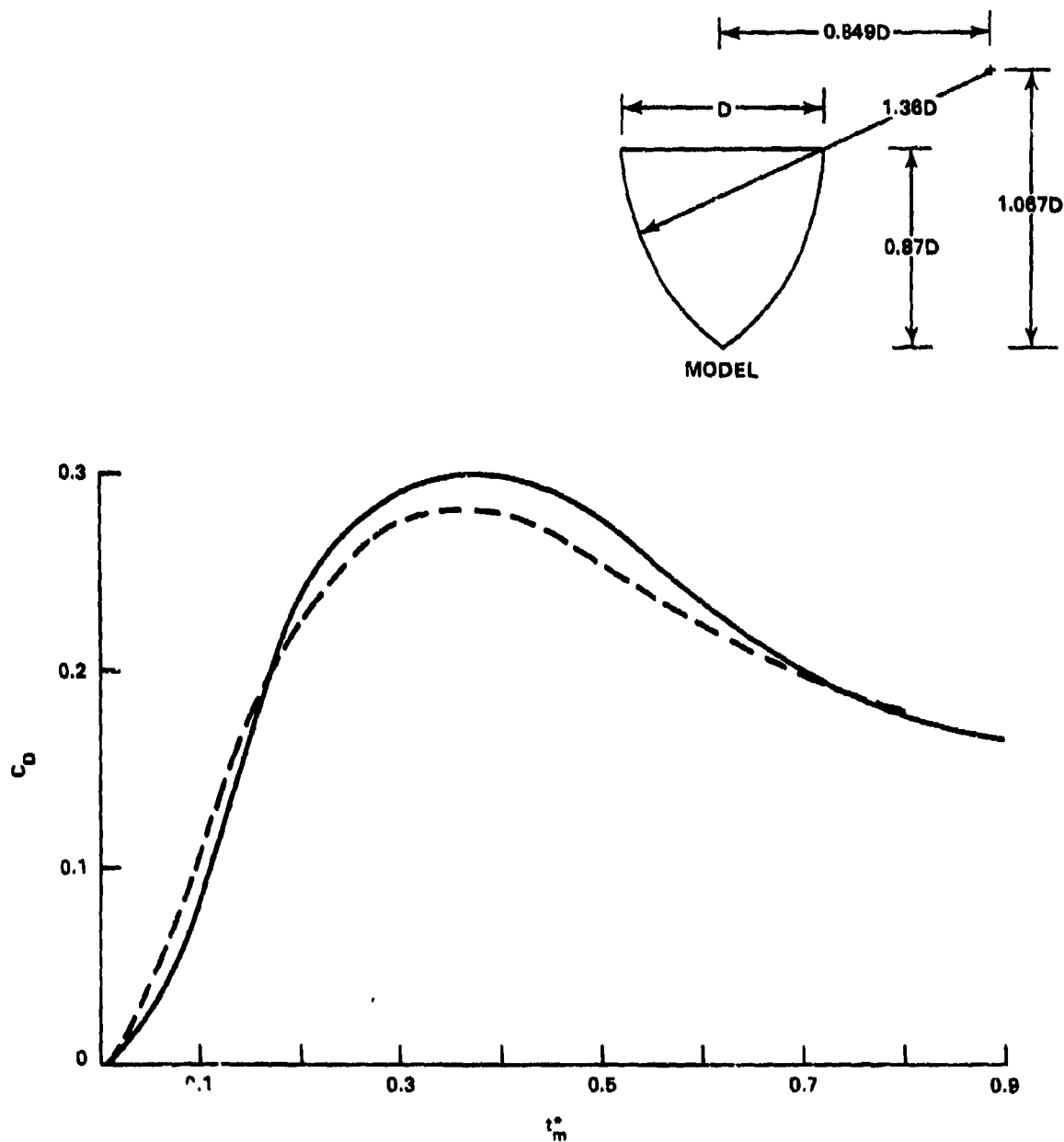


FIG. 22 CALCULATED AND MEASURED DRAG ON A VERTICALLY ENTERING OGIVE.
 -- CALCULATED — MEASURED¹⁰.

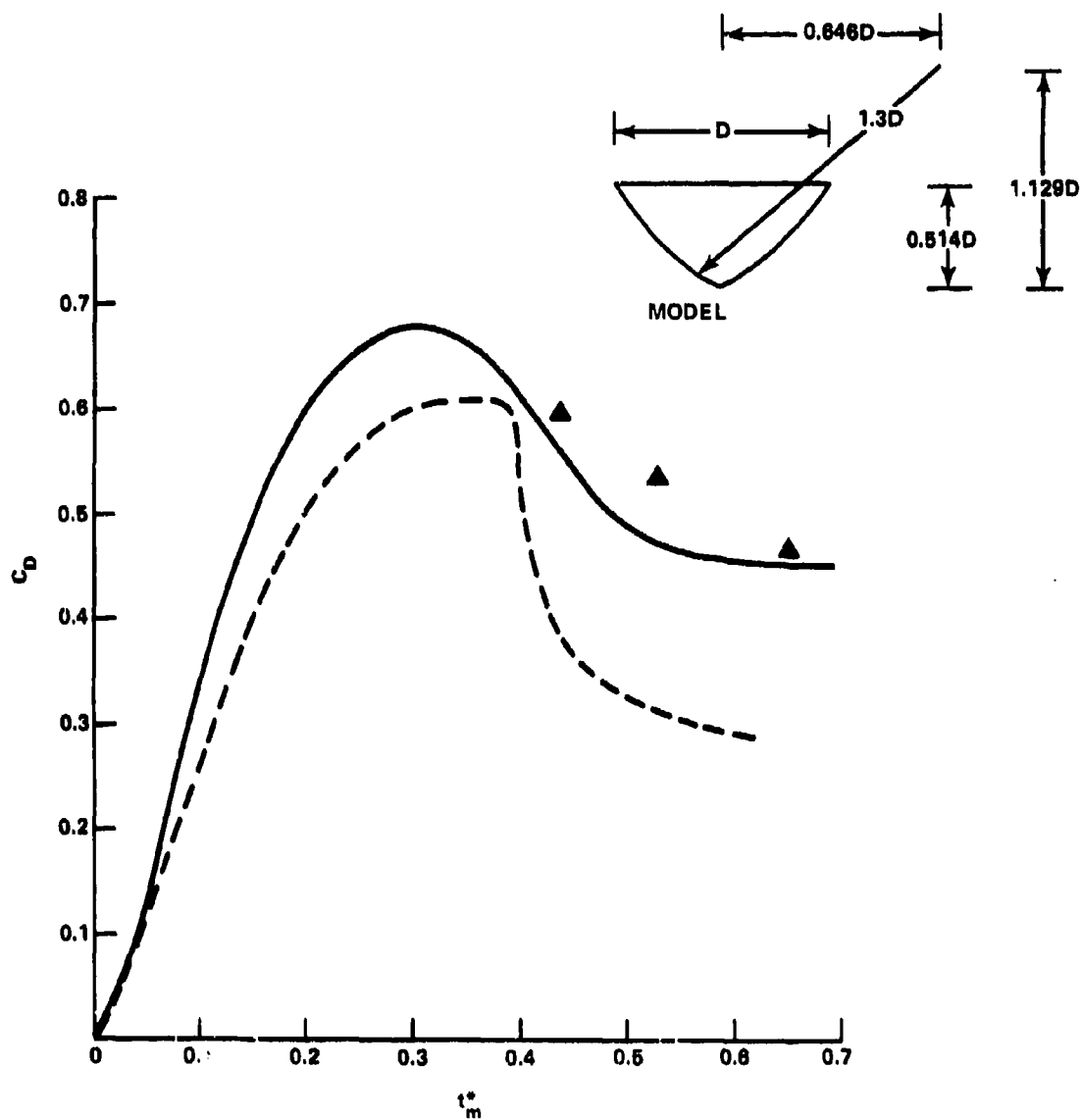


FIG. 23 CALCULATED AND MEASURED DRAG ON A VERTICALLY ENTERING OGIVE. — — CALCULATED
 — — MEASURED¹⁶. ▲ CALCULATED WITH A CAVITY SIMULATED BY NO LOAD ELEMENTS.

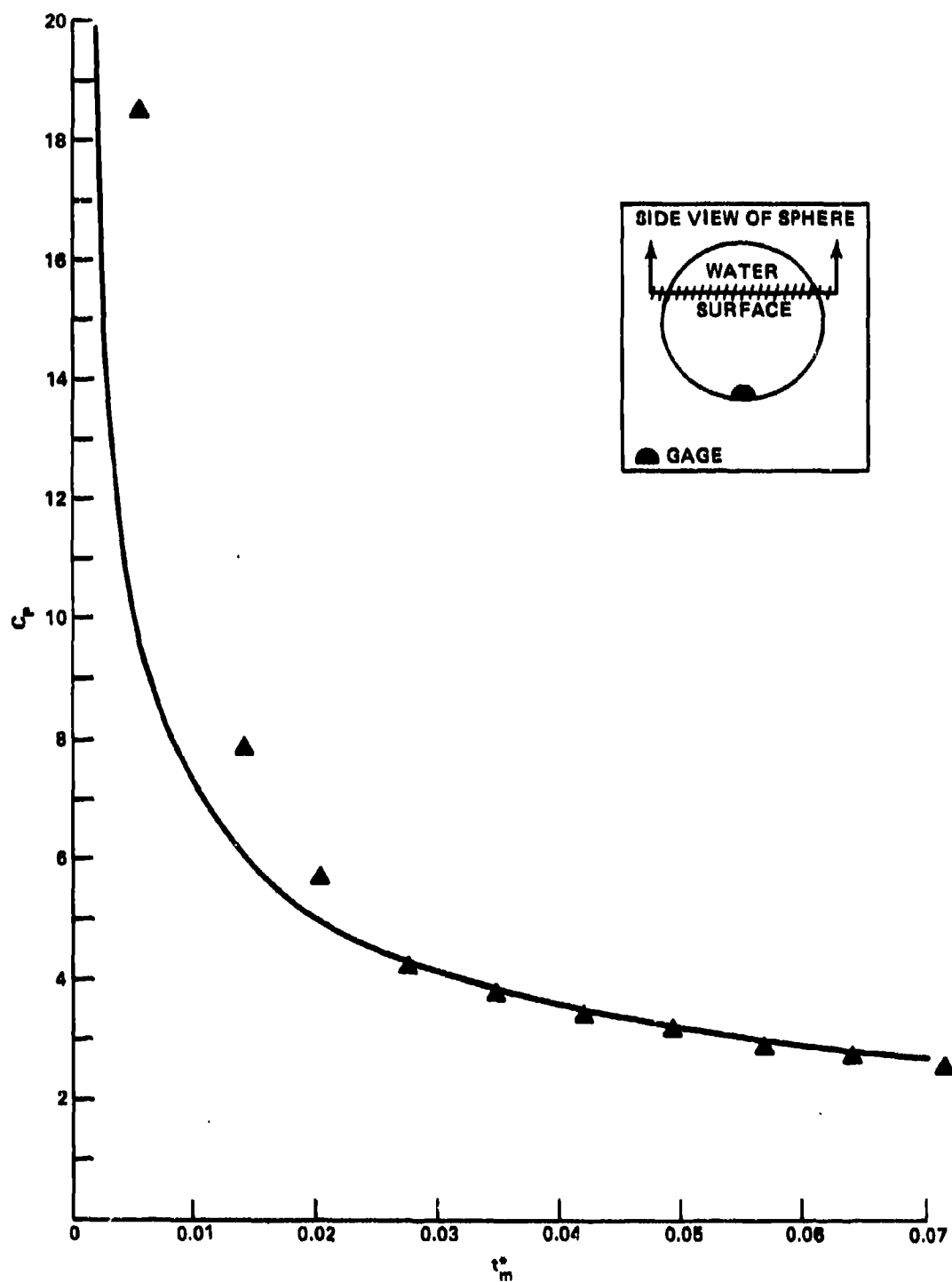


FIG. 24 CALCULATED AND MEASURED STAGNATION PRESSURE ON A SPHERE ENTERING VERTICALLY AT 23.5 FT/SEC. — MEASURED BY NISEWANGER¹⁷ ▲ COMPUTED USING A C_w VALUE DEFINED BY EQUATION (26).

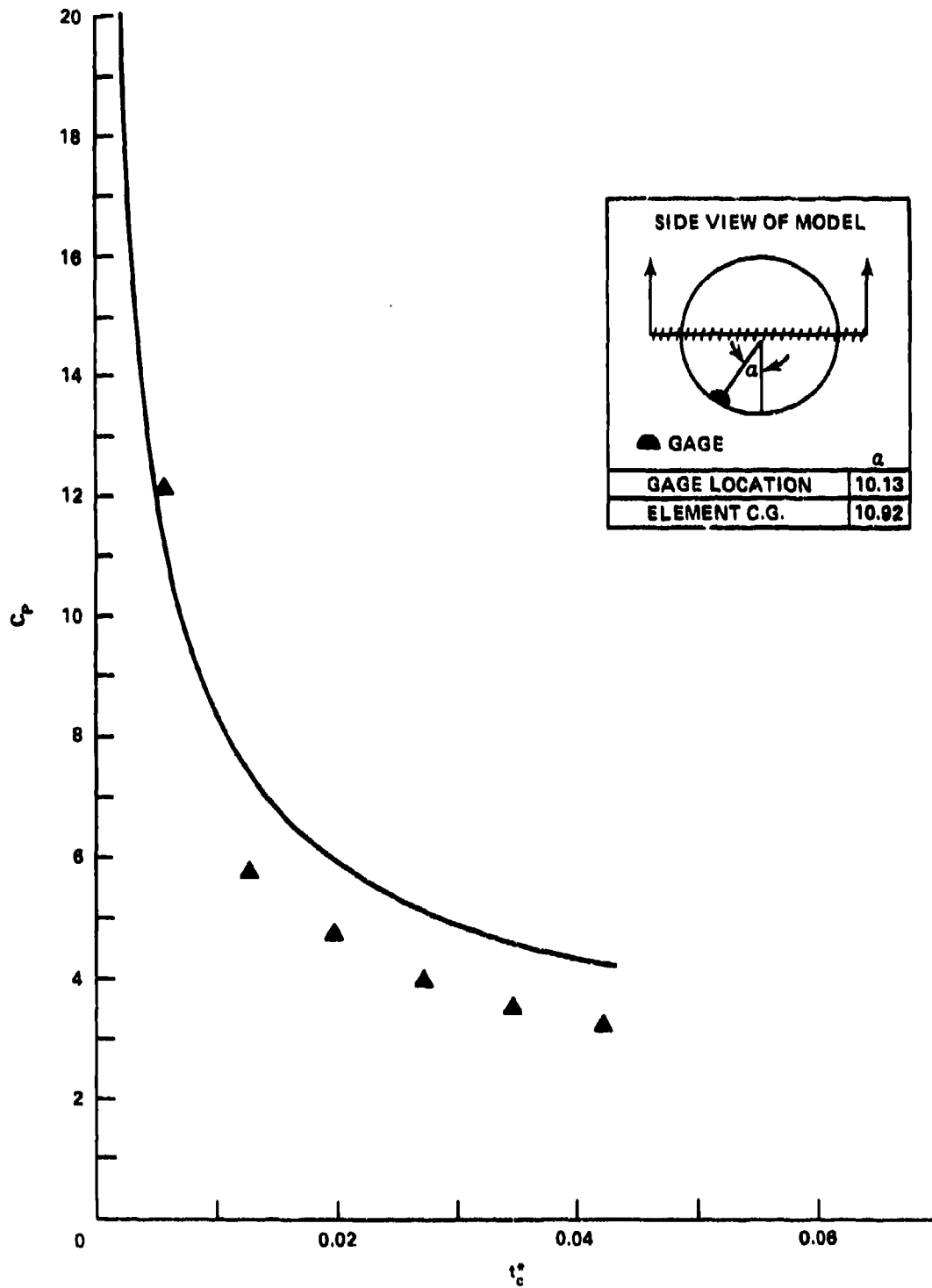


FIG. 25 CALCULATED AND MEASURED PRESSURE COEFFICIENT ON A VERTICALLY ENTERING SPHERE.
 — MEASURED BY NISEWANGER¹⁷ ▲ CALCULATED USING THE C_w FACTOR DEFINED BY
 EQUATION (26).

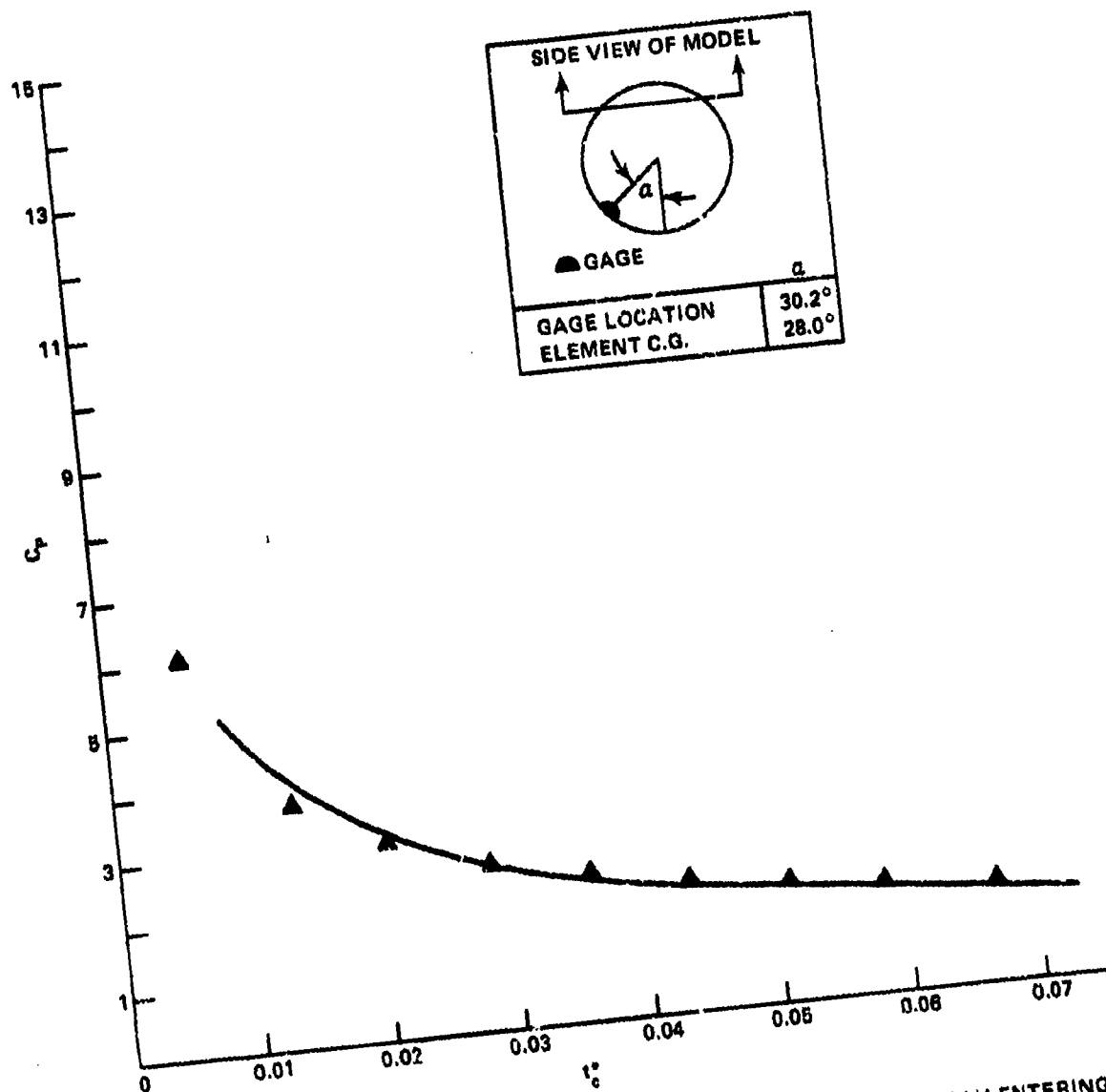


FIG. 26 CALCULATED AND MEASURED PRESSURE COEFFICIENT ON A VERTICALLY ENTERING SPHERE. — MEASURED BY NISEWANGER¹⁷ ▲ CALCULATED USING THE C_w FACTOR DEFINED IN EQUATION (29).

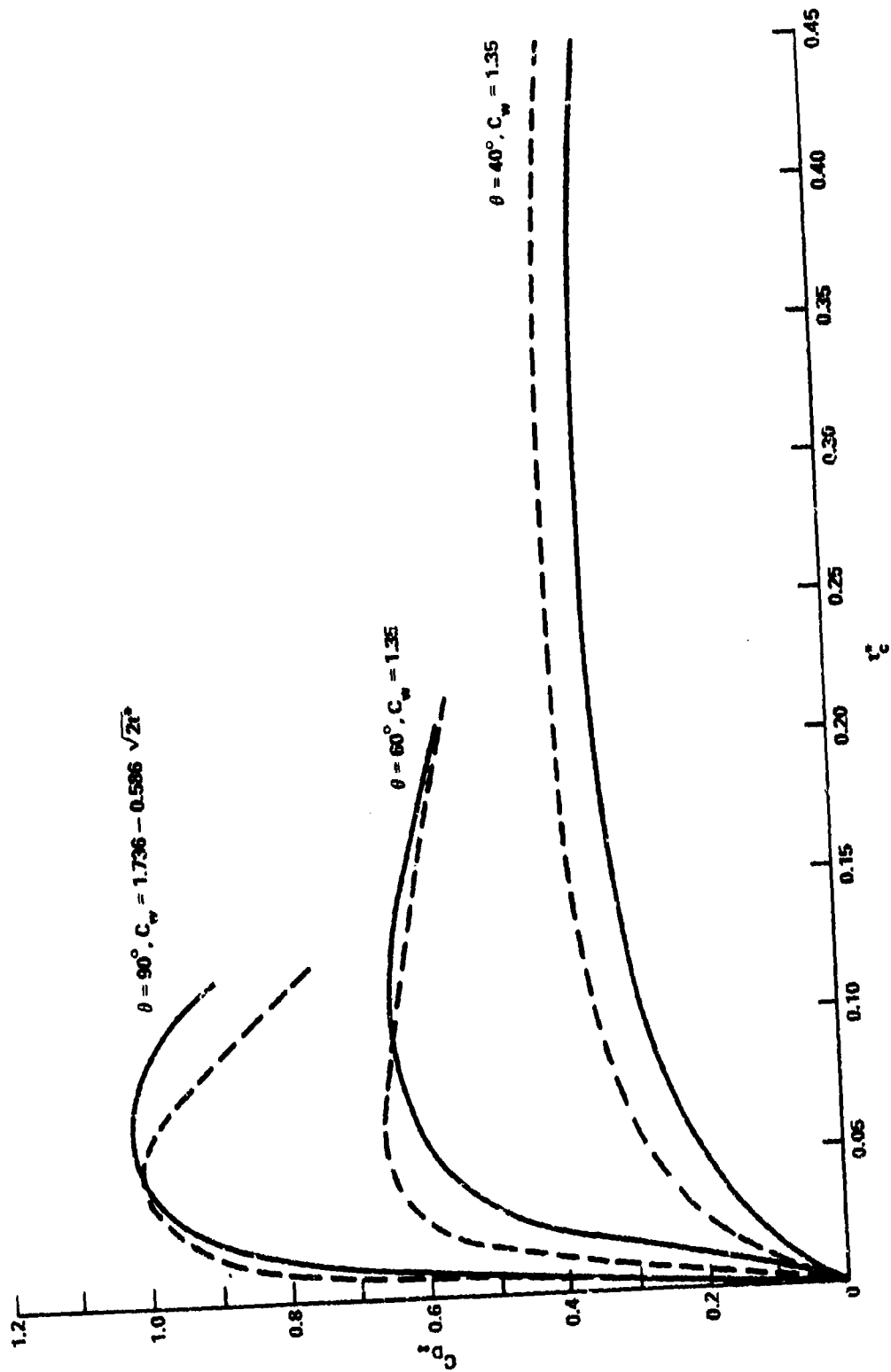


FIG. 27 CALCULATED AND MEASURED DRAG ON A SPHERE AT VARIOUS ENTRY ANGLES. — CALCULATED. - - - MEASURED

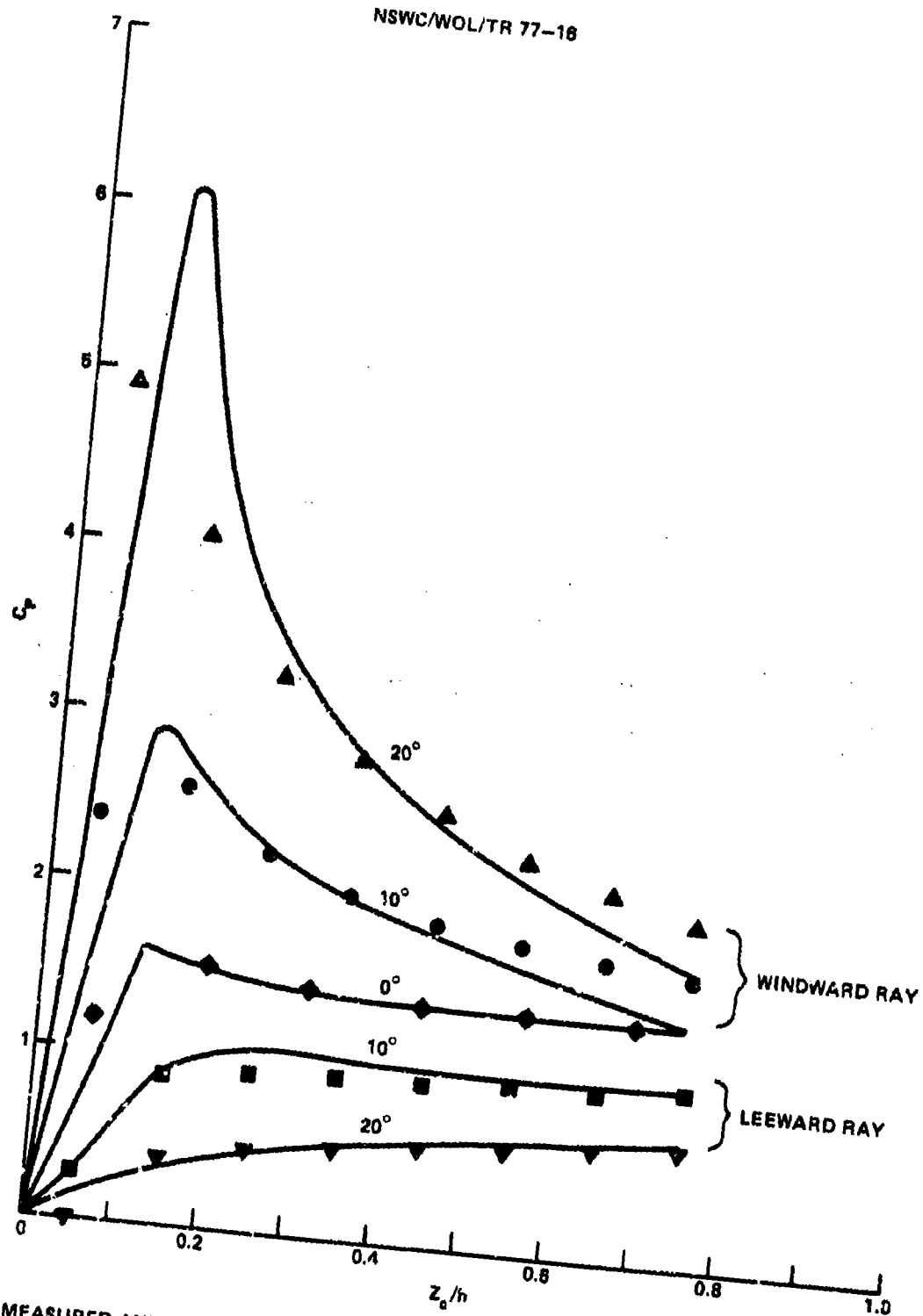


FIG. 28 MEASURED AND CALCULATED PRESSURE DISTRIBUTION ON A VERTICALLY ENTERING 45 DEGREE HALF-ANGLE CONE AT 0, 10, 20 DEGREE INCIDENCE. — UNPUBLISHED EXPERIMENTAL DATA BY BALDWIN. SOLID SYMBOLS ARE CALCULATIONS.

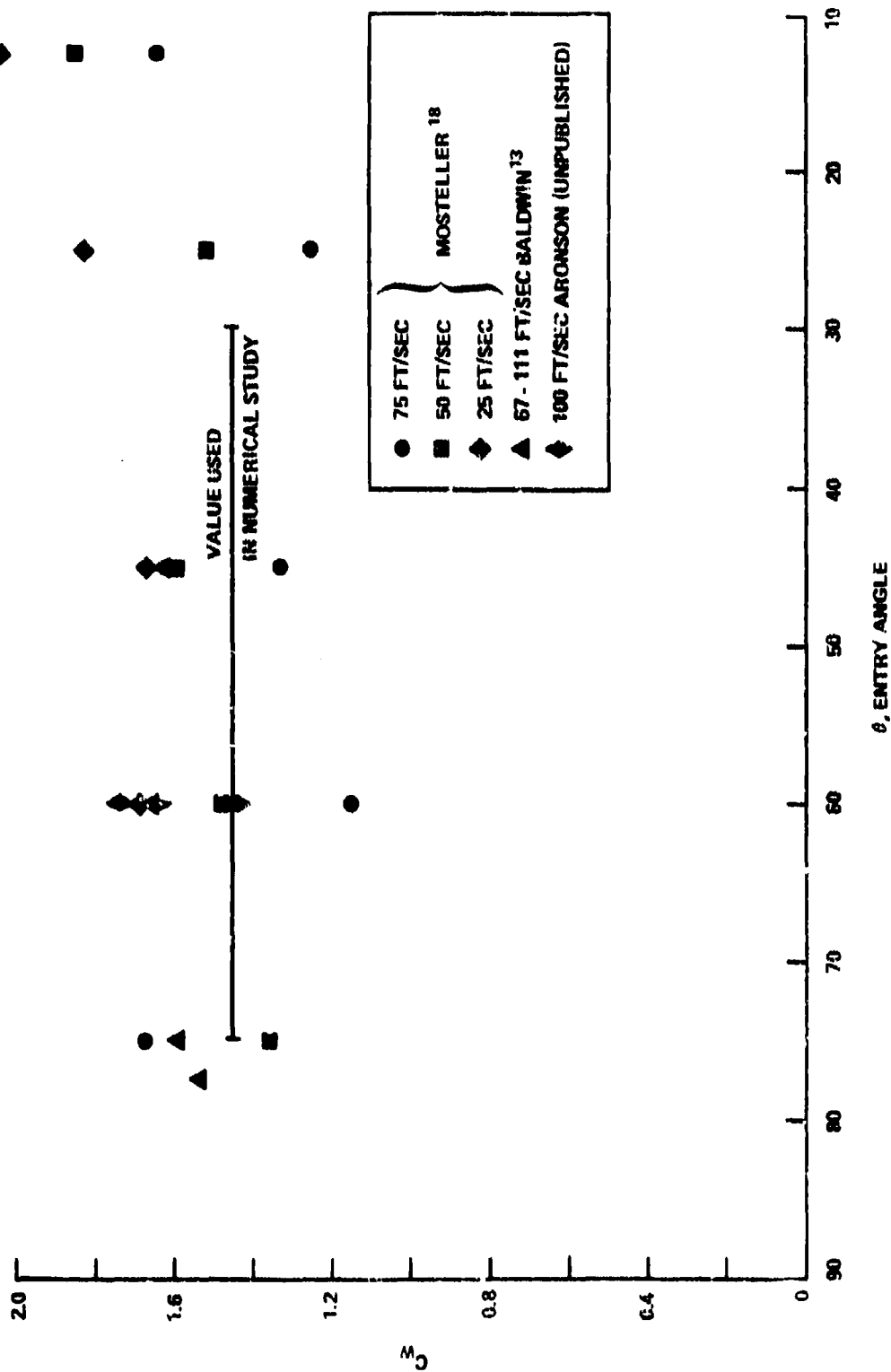


FIG. 29 EXPERIMENTALLY DETERMINED VALUES OF C_w FOR THE OBLIQUE ENTRY OF A DISK CYLINDER.

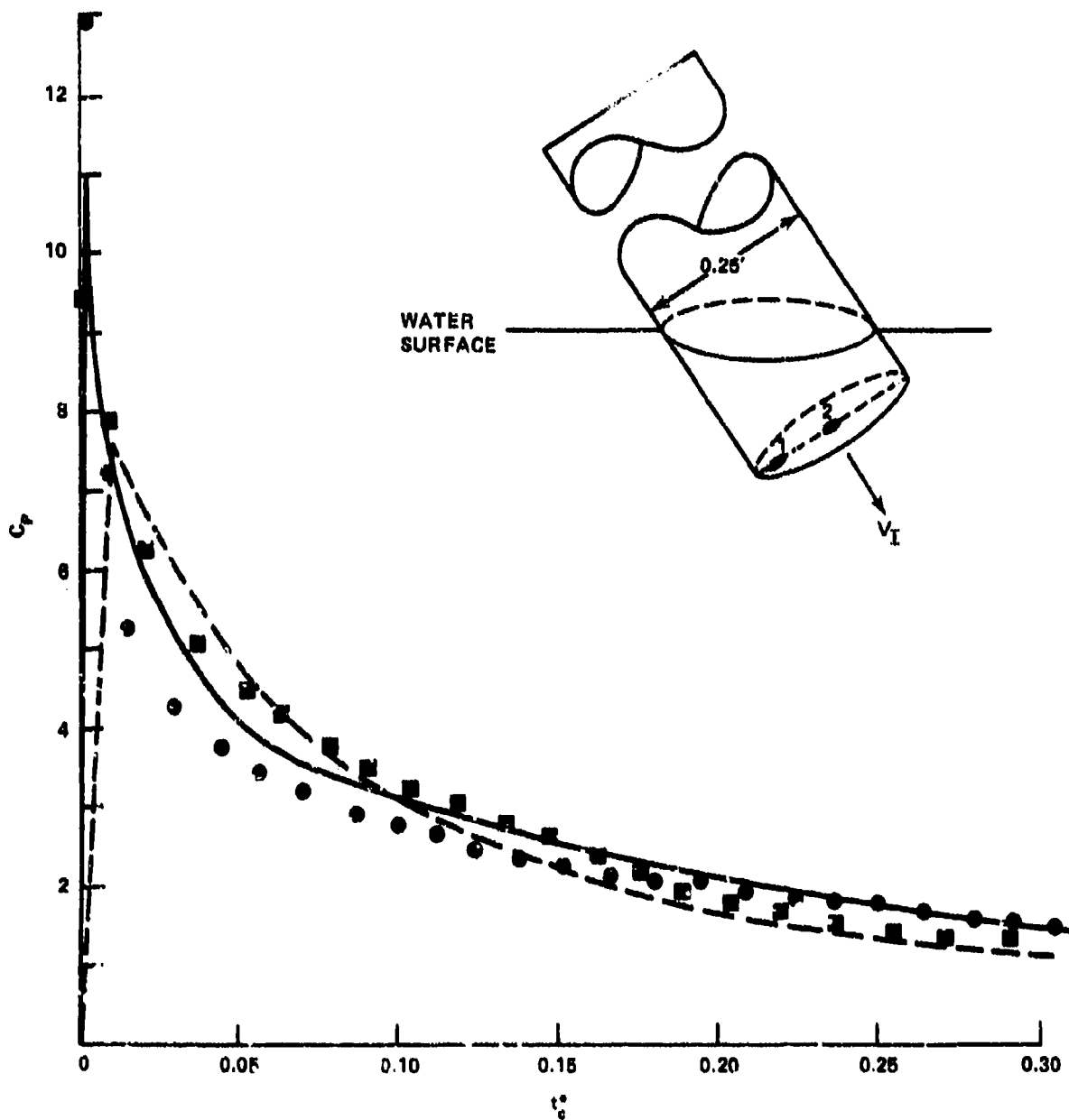


FIG. 30 CALCULATED AND MEASURED PRESSURE-TIME HISTORIES AT TWO DIFFERENT POSITIONS ON THE SURFACE OF A DISK CYLINDER, $\theta = 60$ AND $V_I = 100$ FT/SEC.
 — MEASURED AT POSITION 1 ($r = 0.098$ $\beta = 4^\circ$) ● CALCULATED AT POSITION 1
 - - - MEASURED AT POSITION 2 ($r = 0$) ■ CALCULATED AT POSITION 2.
 MEASUREMENTS BY ARONSON.

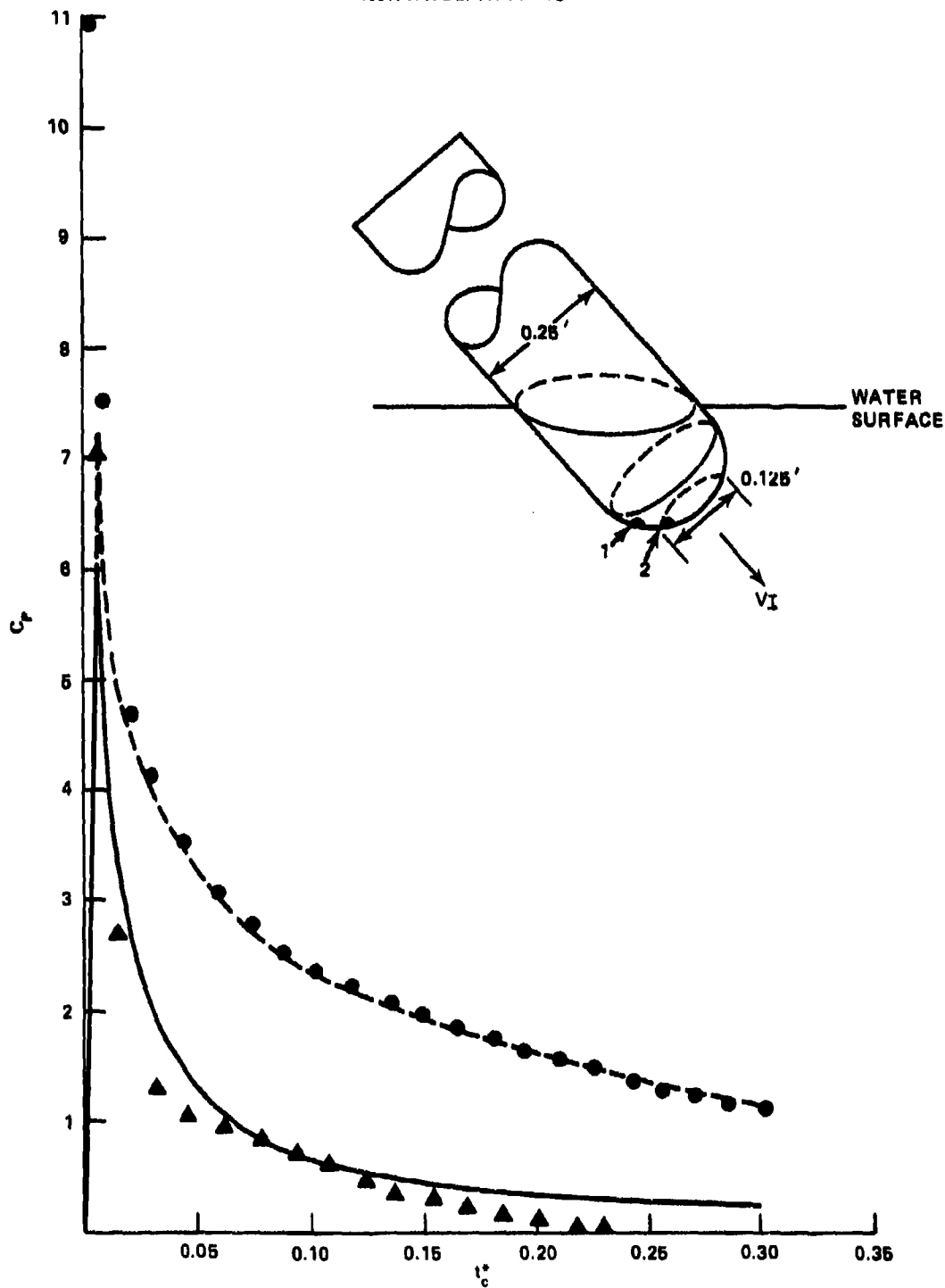


FIG. 31 CALCULATED AND MEASURED PRESSURE-TIME HISTORIES AT TWO DIFFERENT POSITIONS ON THE SURFACE AT AN OGIVE CYLINDER, $\theta = 60$ DEGREES AND $V_1 = 100$ FT/SEC. — MEASURED AT POSITION 1 ($r = 0.112'$, $\beta = 9.5^\circ$) \blacktriangle CALCULATED AT POSITION 1. --- MEASURED AT POSITION 2 ($r = 0.083'$, $\beta = 5.5^\circ$) \bullet CALCULATED AT POSITION 2. MEASUREMENTS ARE BY ARONSON

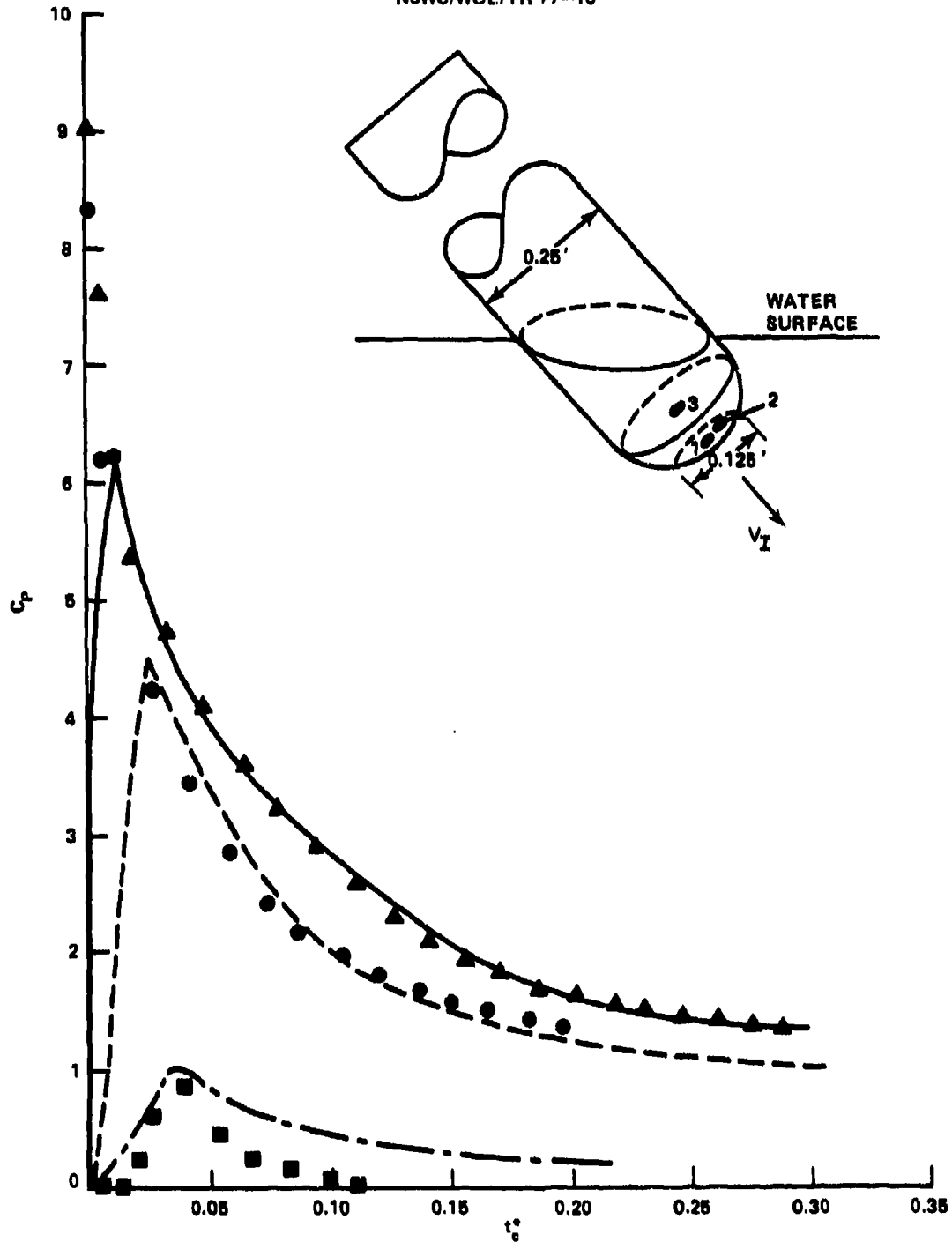


FIG. 32 CALCULATED AND MEASURED PRESSURE-TIME HISTORIES AT THREE DIFFERENT POSITIONS ON THE SURFACE OF AN OGIVE CYLINDER, $\Theta 60$ AND $V_T = 100$ FT/SEC. — MEASURED AT POSITION 1 ($r = 0$) \blacktriangle CALCULATED AT POSITION 1. --- MEASURED AT POSITION 2 ($r = 0.048'$, $\beta = 90^\circ$) \bullet CALCULATED AT POSITION 2. --- MEASURED AT POSITION 3 ($r = 0.112'$, $\beta = 90^\circ$) \blacksquare CALCULATED AT POSITION 3. DATA ARE BY ARONSON

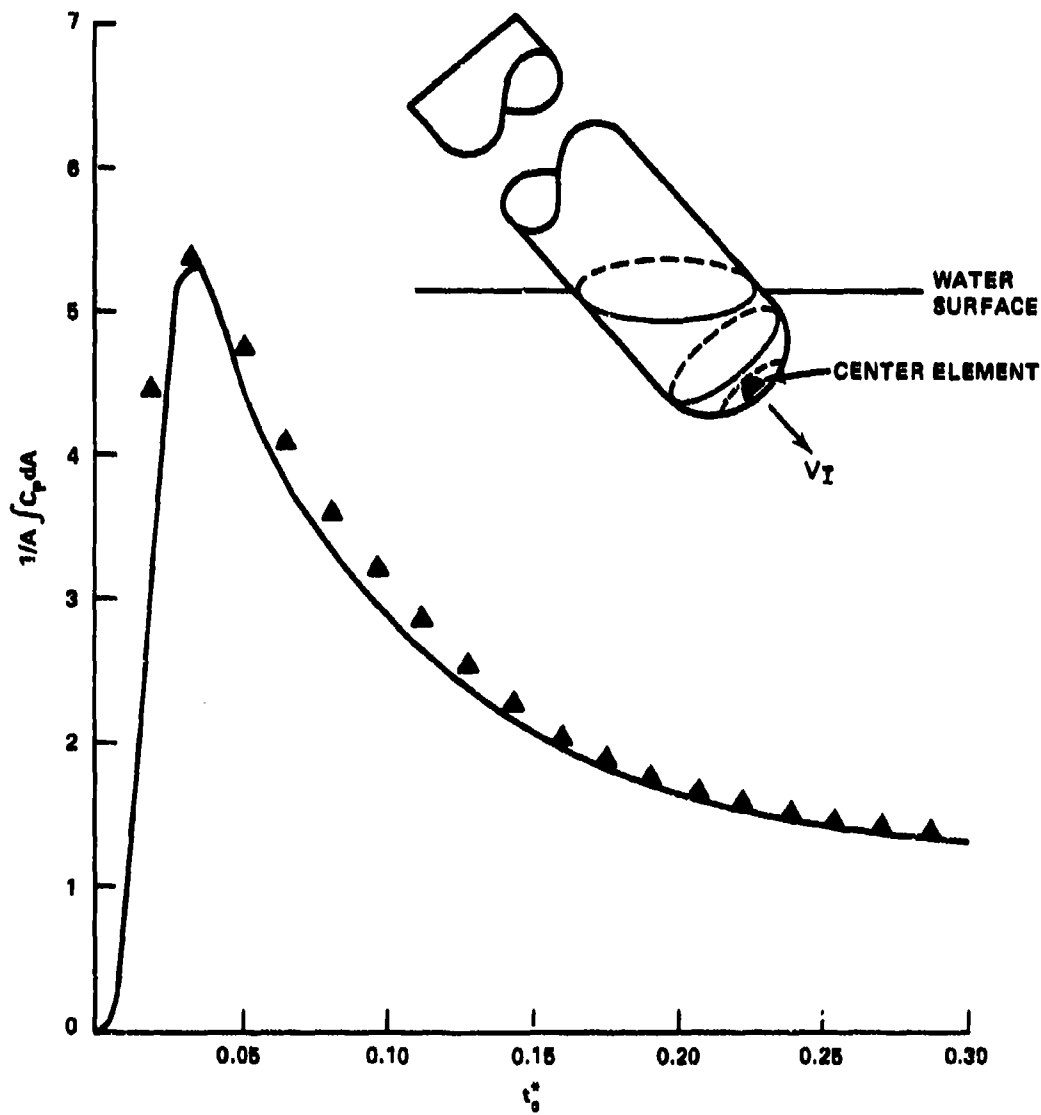


FIG. 33 CALCULATED AND EXPERIMENTAL LOAD ON THE CENTER ELEMENT OF THE OGIVE CYLINDER MODEL. Δ CALCULATED. — EXPERIMENTAL.

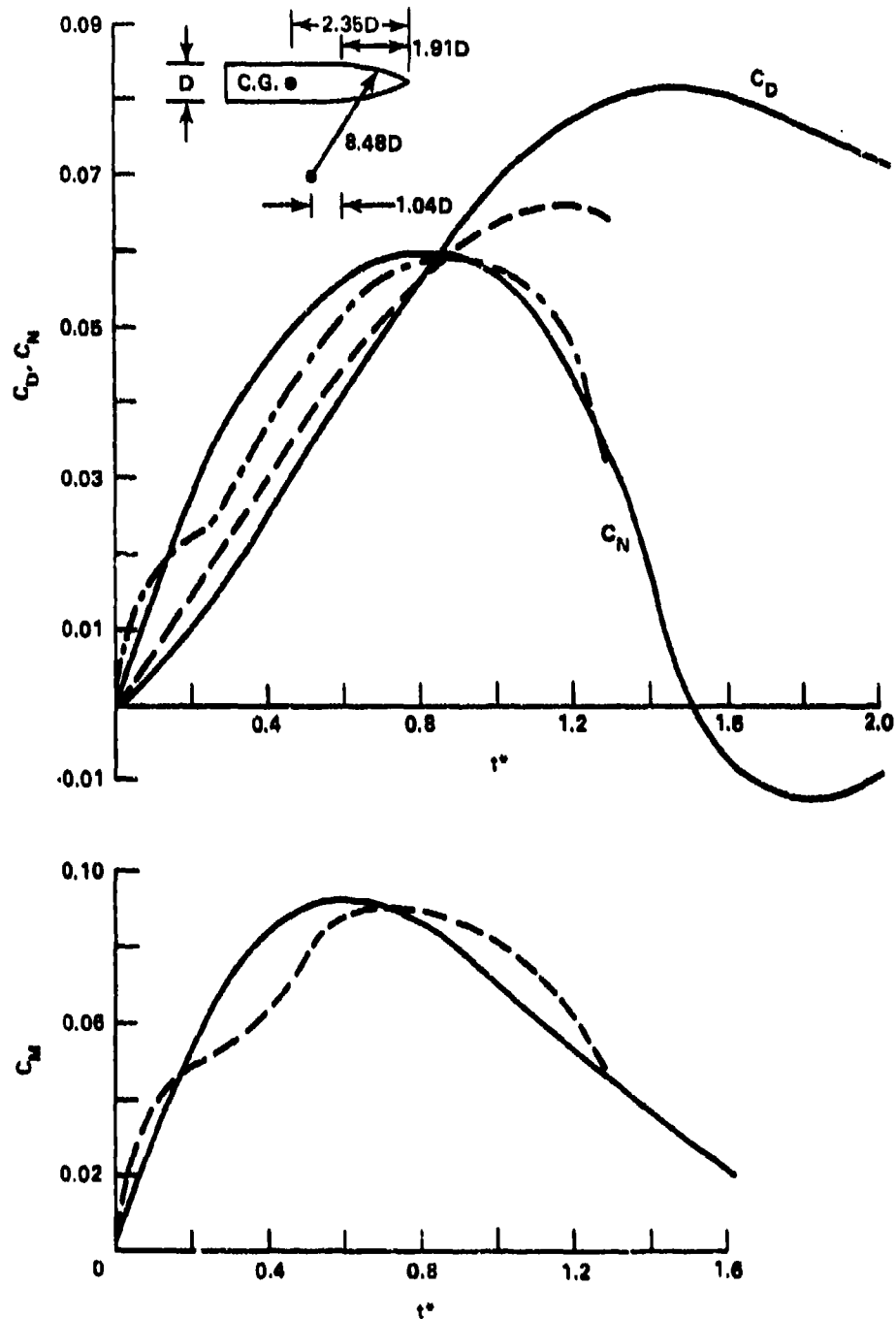


FIG. 34 MEASURED AND CALCULATED DRAG, PITCHING MOMENT AND NORMAL FORCE ON A SLENDER OGIVE ENTERING AT $\theta = 45^\circ$ AND $V_I = 100$ FT/SEC. SOLID CURVES ARE DATA BY BALDWIN. DOTTED AND DASHED CURVES ARE CALCULATED RESULTS.

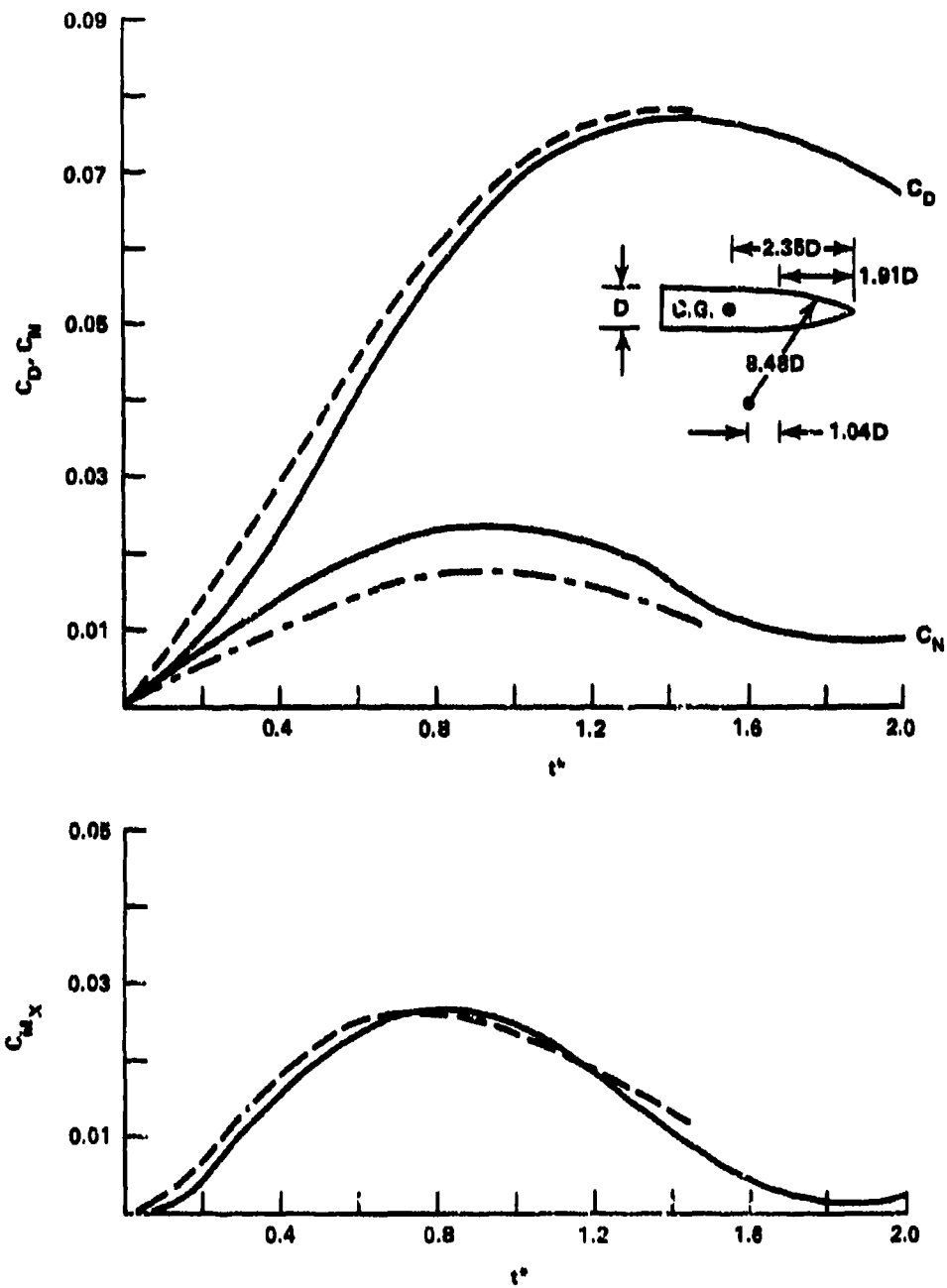


FIG. 35 MEASURED AND CALCULATED DRAG, PITCHING MOMENT AND NORMAL FORCE ON A SLENDER OGIVE ENTERING AT $\theta = 75^\circ$ AND $V \sim 100$ FT/SEC. SOLID CURVES ARE DATA BY BALDWIN. DOTTED AND DASHED CURVES ARE CALCULATED RESULTS.

APPENDIX A

FORMULAS FOR THE INFLUENCE OF PLANAR, QUADRILATERAL ELEMENTS

This section lists formulas for calculating the influence of planar elements on arbitrary points in space, x, y, z . These expressions are taken from reference (11) and are listed here for the sake of completeness. The symbols to be used are defined in Figure A-1. Calculations are carried out using the element coordinate system and hence the velocity components are referenced to these axis:

$$V_{\xi} = -s_{12}Q_{12} - s_{23}Q_{23} - s_{34}Q_{34} - s_{41}Q_{41}$$

$$V_{\eta} = c_{12}Q_{12} + c_{23}Q_{23} + c_{34}Q_{34} + c_{41}Q_{41}$$

$$V_{\gamma} = \text{sign}(z)[\Delta\theta - J_{12} - J_{23} - J_{34} - J_{41}]$$

$$\phi = \phi_{12} + \phi_{23} + \phi_{34} + \phi_{41} - |z|\Delta\theta$$

where:

$$\Delta\phi = 0 \text{ unless } R_{12}, R_{23}, R_{34}, R_{41} > 0 \text{ Then } \Delta\phi \text{ is } 2\pi$$

$$\phi_{ij} = R_{ij}Q_{ij} + |z|J_{ij}$$

$$R_{ij} = (x - \xi_i)s_{ij} - (y - \eta_i)c_{ij}$$

$$Q_{ij} = \frac{1}{n} \left[\frac{r_i + r_j + d_{ij}}{r_i + r_j - d_{ij}} \right]$$

$$J_{ij} = \text{sgn}(R_{ij}) \left[\tan^{-1} \left(\left| \frac{z}{R_{ij}} \right| \frac{s_{ij}^j}{r_j} \right) - \tan^{-1} \left(\left| \frac{z}{R_{ij}} \right| \frac{s_{ij}^1}{r_i} \right) \right]$$

$$r_i = [(x - \xi_i)^2 + (y - \eta_i)^2 + z^2]^{1/2}$$

$$s_{ij}^k = (\xi_k - x)c_{ij} + (\eta_k - y)s_{ij}$$

$$c_{ij} = \frac{\xi_j - \xi_i}{d_{ij}}$$

$$s_{ij} = \frac{\eta_j - \eta_i}{d_{ij}}$$

$$d_{ij} = [(\xi_j - \xi_i)^2 + (\eta_j - \eta_i)^2]^{1/2}$$

At large distances from the element ($r_o/t > 4$), the element may be treated as a point source.. This greatly simplifies calculation of the velocity and potential:

$$\phi = \frac{I}{r_o}$$

$$v_z = z \frac{I}{r_o^3}$$

$$v_\xi = \frac{x}{r_o^3} I$$

$$I = \frac{1}{2} (\xi_3 - \xi_1)(\eta_2 - \eta_4)$$

$$v_{\eta} = \frac{y}{r_o^3} I$$

The equations for ϕ and \bar{V} can be evaluated in any coordinate system. The final velocity components will be referenced to whatever system is used. At intermediate distances from the element, $2.45 < r_o/t < 4$, multipole expansions are used to evaluate the influence coefficients.

$$\phi = I_{00}w + \frac{1}{2}(I_{20}w_{xx} + 2I_{11}w_{xy} + I_{02}w_{yy})$$

$$v_\xi = -\frac{\partial \phi}{\partial x} = -I_{00}w_x - \frac{1}{2}(I_{20}w_{xxx} + 2I_{11}w_{xxy} + I_{02}w_{xyy})$$

$$v_\eta = -\frac{\partial \phi}{\partial y} = -I_{00}w_y - \frac{1}{2}(I_{20}w_{xyx} + 2I_{11}w_{xyy} + I_{02}w_{yyy})$$

$$v_\gamma = -\frac{\partial \phi}{\partial z} = -I_{00}w_z - \frac{1}{2}(I_{20}w_{xxz} + 2I_{11}w_{xyz} + I_{02}w_{yyz})$$

where:

$$w = r_o^{-1}$$

$$w_{xxx} = 3x(3p + 10x^2)r_o^{-7}$$

$$w_x = -xr_o^{-3}$$

$$w_{xxy} = 3ypr_o^{-7}$$

$$w_y = -yr_o^{-3}$$

$$w_{xyy} = 3xqr_o^{-7}$$

$$w_z = -zr_o^{-3}$$

$$w_{yyy} = 3y(3q + 10y^2)r_o^{-7}$$

$$w_{xx} = -(p + 2x^2)r_o^{-5}$$

$$w_{xxz} = 3zpr_o^{-7}$$

$$w_{xy} = 3xyr_o^{-5}$$

$$w_{xyz} = -15xyzr_o^{-7}$$

$$w_{yy} = -(q + 2y^2)r_o^{-5}$$

$$w_{yyz} = 3zqr_o^{-7}$$

$$p = y^2 + z^2 - 4x^2$$

$$q = x^2 + z^2 - 4y^2$$

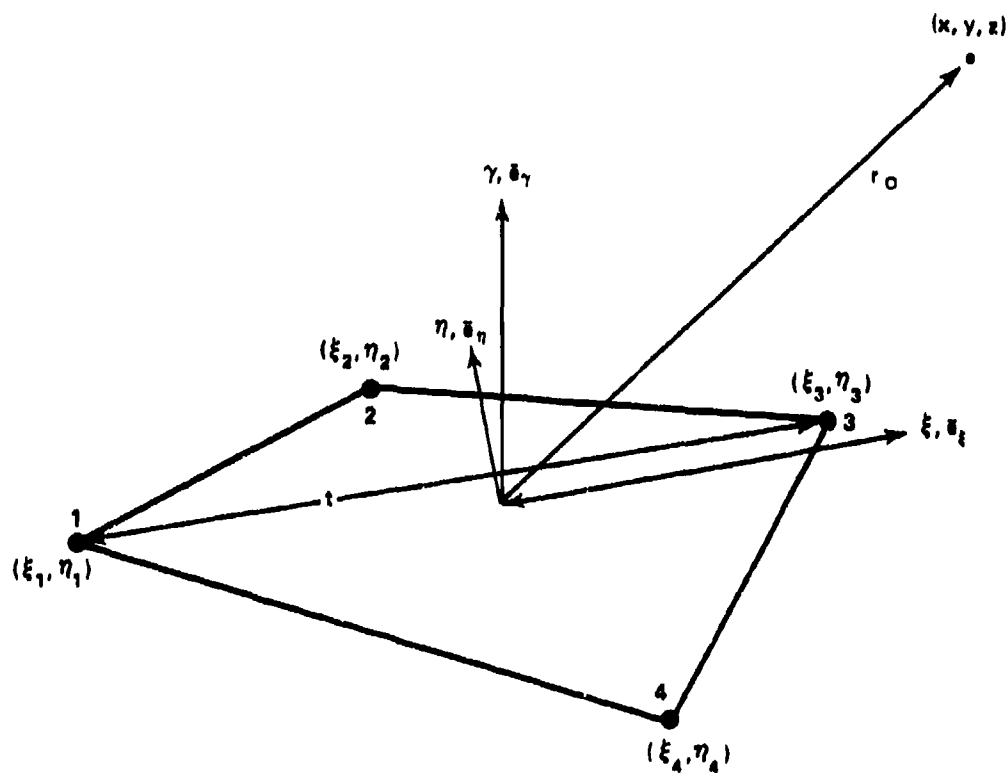


FIG. A-1 SYMBOLS

FIG. A-1 COORDINATE SYSTEM

APPENDIX B

DESCRIPTION OF THE COMPUTER PROGRAM

The computer program consists of the main routine, ENTRY, eighteen subroutines and one function. The flow chart for the program is given in Table B-1 and the main program variables are listed in Table B-2. A program listing is provided in Table B-3.

Program execution is initiated in ENTRY by calling subroutine INDATA which reads the required input (see Appendix C for a description of input cards). Based on options specified by the user a grid is set up on the surface of the model using subroutines STANG, LISTG, and OGTVG. Node points describing the surface of the body are stored in body (x' , y' , z') and water surface coordinates (x , y , z) in arrays X and XT respectively. The identification numbers of the four nodes defining the Jth element are stored in array IN(1, J), IN(2, J), IN(3, J) and IN(4, J). The coordinates of each node point, nodes making up each element and element centroids are printed in subroutine ELEMST. This terminates the element definition portion of the program which is executed only once.

The following sequence is executed at each step. The center of gravity of the entry body is inserted the prescribed increment in depth and the corresponding position of each node point is calculated by subroutine ADVN. Subroutine CREL is called which examines all elements to determine which are submerged. Elements split by the water surface are redefined using new node points which located on the water surface and stored at the ends of arrays X and XT. The nodes making up submerged elements are stored sequentially in array IT. The original reference number of each submerged element is stored in array IQ and the code indicating its state (i.e., modified, unmodified or split) in array IM. Upon completion of subroutine CREL, MAN is called which calculates the area, centroid and unit vectors of each element. If the PRINT option is used, element information is printed out by ELEMST for elements which are modified or unmodified for the first time. This information includes centroid and node locations in both coordinate systems, element areas and unit vector components. The arrays X, XT, IN, XC, XCP, VNO, E, IT, PHIO, IQ, IM are written on TAPE 15 by ENTRY. The coefficients of matrices A, B, C, and D are calculated by subroutine AMAT using the equations of Appendix A and written on TAPE 16. To determine the induced velocity normal to each element centroid (i.e., the right hand side of equation (13)) subroutine VNORM is called. The source strengths of equation (13) are calculated using DDECOMP and DSOLVE. These subroutines are called from SUAS which sets up matrix A in appropriate blocks using information on Tape 16. The element information stored on TAPE 15 and the matrices B, C, and D stored on TAPE 16 are recalled to allow velocity and potential values to be calculated at each centroid element in subroutine OUTPUT using equation (14). If the PRINT option is used, this information is also printed. Data necessary for calculating pressures and loads are stored on TAPE 17.

The above procedure is repeated until termination occurs. This can be triggered by reaching a step number greater than IMAX, having the number of submerged elements exceed NDM, or having the computational time approach the job time limit. This last option is necessary since pressures and loads, of principal concern, are calculated at the end of the program. To insure that these quantities are computed the code estimates the amount of time required to complete each step before starting it. If the total estimated time estimated exceeds 90 percent of the job time limit, the flow field calculation is terminated and the program branches to subroutine PRESF which calculates pressures and loads using the equations (18) through (21).

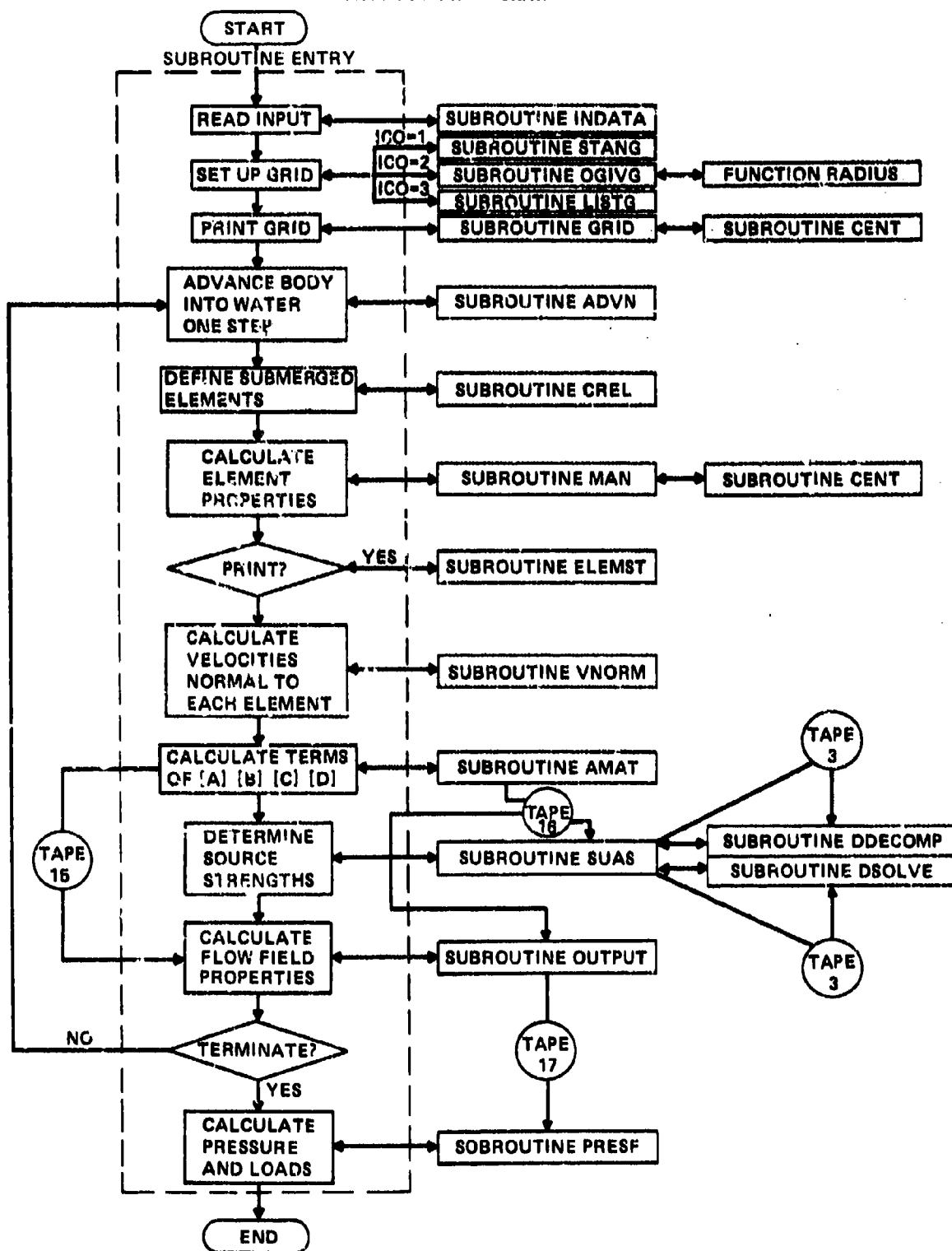
TABLE B-1
PROGRAM FLOW CHART

TABLE B-2

MAIN VARIABLES

<u>VARIABLE</u>	<u>TYPE</u>	<u>DEFINITION</u>
AN,AX,AY,ANS, AXS,AYS	ARRAY	TEMPORARY STORAGE IN AMAT AND OUTPUT
CGL	SIMPLE	z' COORDINATE OF CENTER OF GRAVITY
CW	ARRAY	WETTING FACTORS USE DURING CONSTANT ORIENTATION ENTRY
CWT(I)	ARRAY	WETTING FACTOR BETWEEN STEPS I-1 AND I
D	SIMPLE	MODEL DIAMETER. USED ONLY IN CALCULATING DIMENSIONLESS QUANTITIES
DT(I)	ARRAY	INCREMENT IN TIME BETWEEN STEPS I-1 AND I
E(I,J,K)	ARRAY	ELEMENT UNIT VECTORS. I= 1,2,3 ARE COMPONENTS ALONG x,y,z AXIS. J = 1,2,3 ARE UNIT VECTORS ξ , η , AND γ RESPECTIVELY. K IS ELEMENT NUMBER
HMIN	SIMPLE	INITIAL MODEL DEPTH
HMAX	SIMPLE	INCREASE IN MODEL DEPTH DUE TO RISING MOTION OF SURFACE
ICON	SIMPLE	IF ICON = 0, CONSTANT ORIENTATION ENTRY IS ASSUMED. IF ICON = 1 VARIABLE ORIENTATION IS USED
IEM	SIMPLE	NUMBER OF SUBMERGED ELEMENTS
IM(I)	ARRAY	I IS ELEMENT NUMBER. IM = 0, IM = 1, AND IM = 2, INDICATE NOT MODIFIED, MODIFIED AND SPLIT ELEMENTS RESPECTIVELY
IN(I,J)	ARRAY	NODES DEFINING CORNER LOCATIONS. I IS THE CORNER NUMBER AND J IS THE ELEMENT NUMBER
INP	SIMPLE	TOTAL NUMBER OF DEFINED NODES. INCLUDES NODES GENERATED TO DESCRIBE MODIFIED ELEMENTS
IP	ARRAY	USED IN DD'COMP AND DSOLVE

TABLE B-2 (Continued)

<u>VARIABLE</u>	<u>TYPE</u>	<u>DEFINITION</u>
IPRINT	SIMPLE	IF IPRINT = 1 PRINT OPTION IS EXERCISED
IPHI	SIMPLE	IF IPHI = 1 PLANAR SYMMETRY IS ASSUMED
IQ(K)	ARRAY	ORIGINAL IDENTIFICATION NUMBER OF SUBMERGED ELEMENTS. K IS THE IDENTIFICATION NUMBER OF THE SUBMERGED ELEMENT
IT(I,K)	ARRAY	IDENTIFICATION NUMBER OF NODES DESCRIBING THE Kth SUBMERGED ELEMENT
NCW	SIMPLE	NUMBER OF WETTING FACTORS TO BE USED DURING CONSTANT ORIENTATION ENTRY
NDIM	SIMPLE	MAXIMUM ALLOWABLE NUMBER OF SUBMERGED ELEMENTS
NEL	SIMPLE	NUMBER OF ELEMENTS INITIALLY DEFINED
PHI	ARRAY	TEMPORARY STORAGE IN AMAT
PHIS	ARRAY	TEMPORARY STORAGE IN OUTPUT
SIG(K)	ARRAY	SOURCE STRENGTH OF ELEMENT K
STOR	ARRAY	TEMPORARY STORAGE IN SUAS
SUMT	SIMPLE	90 PERCENT OF TIME LIMIT
VENTRY	SIMPLE	ENTRY VELOCITY
VEX(I), VEY(I), VEZ(I)	ARRAY	VELOCITY COMPONENTS IN THE x,y, AND z DIRECTION USED BETWEEN STEPS I AND I-1
VNO(I)	ARRAY	VELOCITY NORMAL TO ELEMENT I
WX(I)	ARRAY	ANGULAR VELOCITY IN THE PITCH PLANE BETWEEN STEPS I AND I-1
X(I,K)	ARRAY	COORDINATES OF THE Kth NODE. I = 1,2,3 REFER TO THE x',y',z' AXES RESPECTIVELY
XC(I,K)	ARRAY	COORDINATES OF THE CENTROID OF THE Kth ELEMENT. I = 1,2,3 REFER TO THE x',y', AND z' AXES RESPECTIVELY

TABLE B-2 (Continued)

<u>VARIABLE</u>	<u>TYPE</u>	<u>DEFINITION</u>
XCP(I,K)	ARRAY	COORDINATES OF THE CENTROID OF THE Kth ELEMENT. I = 1,2,3 REFER TO THE x,y, AND z AXIS RESPECTIVELY
XCPB(I)	ARRAY	COORDINATES OF THE CENTER OF GRAVITY. I = 1,2,3 REFER TO THE x,y,z AXES RESPECTIVELY
XT(I,K)	ARRAY	COORDINATES OF THE Kth NODE. J = 1,2,3 REFER TO THE x,y,z AXES

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FIN 4.5-410

PROGRAM ENTRY 73/73 OPT=1

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60      CALL INDATA(IPRINT,IPHI,IMODE,IGRID,IMAX,MIN,ICOM,SUMT,
      *SUM,DT,CNT,CN,VEZ,VEY,VEZ,UX,ANG,XCPB,CGL,VENTRY,MCM,MMLD,FCF)
      C.....SET UP GRID
      MM=IGRID(1):1
      DO 4 I1=2,MM
      IGO=IGRID(I1)
      IF (ICQ.EQ.1) CALL STANG(NPT,MEL,ANG,X,XT,IN,XCPB,MIN,ZTC,YTC)
      IF (ICQ.EQ.2) CALL OGVG(NPT,MEL,ANG,X,XT,IN,XCPB,MIN,ZTC,YTC)
      IF (ICQ.EQ.3) CALL LISTG(NPT,MEL,ANG,X,XT,IN,XCPB,MIN,ZTC,YTC)
      4 CONTINUE
      CALL GRID(NPT,MEL,X,XT,IN,PHIO,KC,ACHECK,MMLD)
      C.....SET MISCELLANEOUS CONSTANTS
      ISTEP=0
      CPC=0.0
      SUM=SECOND(100)
      DO 15 J=1,2
      DO 15 I=1,MEL
      15 PHIO(J,I)=0.0
      C.....MAIN LOOP
      20 ISTEP=ISTEP+1
      IF (ISTEP.NE.1) READ(15)A
      REWIND 15
      C.....ADVANCE ALL MODES
      CALL ADVSTAT(VEZ,VEY,VEZ,CNT,UX,ANG,XCPB,ISTEP,NPT,DT,DOZ,
      *MMAX)
      C.....DETERMINE WHICH ELEMENTS ARE VALID
      CALL CRELX(IN,IT,IO,IN,IER,NPT,MEL,ANG,IMP,XT,XCPB,CGL,ACHECK)
      IF (IER.GT.NM) GO TO 21
      C.....CALCULATE ELEMENT VECTORS,CENTROIDS AND TRANSFORM MODES FROM
      C.....BODY TO WATER COORDINATES
      CALL MAN(X,IT,XT,KC,XCP,IER,ANG,PHIO,IG,XCPB,CGL,E)
      XIER2=IER+IER
      IF (CPC+XIER2>SUM+SUMF,GT,SUMT) GO TO 21
      IF (IPRINT.EQ.1.AND.NPT.NE.IMP) CALL ELEWST(IMP,NPT,IT,IER,IO,IN,
      1X,XT,KC,XCP,E,PHIO,ISTEP,MMAX)
      CALL VMORMIVEZ(VEY,VEZ,UX,VND,E,IER,ISTEP,XCP,XCPB,IPRINT)
      WRITE(15)A,IP
      REWIND 15
      C.....CALCULATE MATRICES
      CALL AMAT(XCP,XT,IT,IER,AN,AT,AX,PHI,VND,F,IPH)
      C.....INVERT MATRIX AND DETERMINE SOURCE STRENGTHS
      CALL SUAS(IER,IAVS,MBLK,A,IP,VND,SIG,STOR)
      C.....CALCULATE FLOW QUANTITIES
      READ(15)A,IP
      REWIND 15
      CALL OUTPUT(IER,IT,IN,ANG,SIG,VND,AN,ANS,AX,AYS,AT,PHI,PHIS,
      *PHIO,KC,XCP,IO,IM,E,IPRINT,DOZ,MMAX,XCPB)
      C.....TERMINATE CHECK
      SUMP=SUM
      SUM=SECOND(100)
      SUMD=SUM-SUMP
      CPC=SUMD/XIER2
      IF (IPRINT.EQ.1) WRITE(16,2031)SUMD
      IF (IPRINT.EQ.0) WRITE(16,2032)ISTEP,SUMD
      2032 FORMAT(1H9,5HSTEP,15,30H COMPLETE,CP TIME FOR STEP IS,10.5)
      2031 FORMAT(1H8,20,18HCP TIME FOR CYCLE,10.5)
      2032 IF (SUMT-SUM,LT,SUMF) GO TO 22

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      ENTRY 48
      DEC27 4
      ENTRY 42
      DEC06 2
      DEC06 3
      DEC06 4
      DEC06 5
      DEC06 6
      JAN10 2
      DEC06 9
      DEC14 3
      ENTRY 48
      MOV03 5
      ENTRY 49
      ENTRY 50
      ENTRY 51
      ENTRY 52
      ENTRY 53
      ENTRY 54
      ENTRY 55
      ENTRY 56
      ENTRY 57
      ENTRY 58
      MOV03 6
      MOV03 7
      ENTRY 66
      MOV15 2
      ENTRY 62
      ENTRY 63
      ENTRY 64
      MOV05 1
      ENTRY 66
      ENTRY 67
      JAN10 3
      JAN10 4
      MOV08 2
      ENTRY 70
      ENTRY 71
      ENTRY 72
      MOV09 1
      ENTRY 74
      JAN01 5
      ENTRY 90
      ENTRY 91
      ENTRY 92
      MOV03 16
      MOV03 11
      ENTRY 95
      ENTRY 96
      ENTRY 97
      ENTRY 98
      ENTRY 99
      ENTRY 100
      ENTRY 101
      ENTRY 102
      ENTRY 103
      ENTRY 104

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PROGRAM ENTRY	73/73	GPT=1	FTN 4.5+410	77/01/17. 11.07.10	PAGE 3
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115      IF (ISTEP-LE.1MAX160 TO 20
          22 ISTEP=ISTEP+1
          21 CONTINUE
          RE=IND 17
          C.....CALCULATE PRESSURE AND FORCES
          CALL PRESF (ISTEP,IMODE,MAX,VEZ,VEY,VEA,MMIN,CU,DT,ICOM,CUT,
          *CGL,ANCH,D,VENTPY,IPHI,NMLD,FCF)
          STOP
          ENU
120

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MOV03      12
ENTRY      106
ENTRY      107
ENTRY      108
ENTRY      109
ENTRY      110
JAN10      5
ENTRY      112
ENTRY      113

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1  SUBROUTINE INDATA(IPRINT,IPHI,IMODE,IGRID,IMAX,IMIN,ICON,SUMT,
   *SUM,D,DT,CUT,CU,VEZ,VEY,VER,MAX,ANG,ICPB,CGL,VENTRY,MCH,MMLD,FCF)
   DIMENSION DT(1),CUT(1),CU(1),VEZ(1),VEY(1),VER(1),MAX(1),XCPB(1),
   *IGRID(1)
5  C.....READ IN OPTIONS
   EPS=1.-06
   CONV=57.29577951
   MCH=1
10  IMODE=0
   READ(5,1000)COM1,COM2
   IF(COM1)
   IF(COM1.EQ.4)MPPIN=1
   IF(COM1.EQ.4)MCON=0
   IF(COM1.EQ.4)MCON=0
   IF(COM1.EQ.4)MCON=0
15  1000 FORMAT(1H,1,36X,29H*****PROGRAM OPTIONS*****1H,36X,2A4,0 800Y
   *ORIENTATION*)
   READ(5,1000)COM1,COM2,COM3
   IPRINT=0
   IF(COM1.EQ.4)MPPIN=1
   IF(COM1.EQ.4)MCON=0
   IF(COM1.EQ.4)MCON=0
   IF(COM1.EQ.4)MCON=0
20  1000 FORMAT(1H,1,36X,3A4)
   READ(5,1000)COM1,COM2,COM3
   IPHI=1
   IF(COM1.EQ.4)MPPIN=1
   IF(COM1.EQ.4)MCON=0
   IF(COM1.EQ.4)MCON=0
   IF(COM1.EQ.4)MCON=0
25  1007 FORMAT(1H,1,36X,2A4,0 0 CONFIGURATION*)
   C.....READ IN COMPOUND PARAMETERS
   READ(5,1000)IMAX,D,ENTRY,ANG,SUMT,MIN,DM,ALPHA
   READ(5,1000)ICGL,FCF,ANG88,MMLD
   IF(MMLD.EQ.0)MMLD=1000
   IF(MMLD.EQ.0)MMLD=1000
30  1000 FORMAT(1H,0,7A1,32H*****PROBLEM PARAMETERS*****
   *1)
   WRITE(6,2001)D
   2001 FORMAT(1H,40X,9H0,AMETER,0F6.4,3H FT)
   WRITE(6,2002)ENTRY
   2002 FORMAT(1H,40X,15HENTRY VELOCITY,0F10.3,8H(FT/SEC))
   WRITE(6,2003)ANG
   2003 FORMAT(1H,40X,8H00Y ORIENTATION ANGLE,0F6.2,8H DEGREES)
   WRITE(6,2004)MIN,IMAX
   2004 FORMAT(1H,40X,13HINITIAL DEPTH,0F10.5,3H FT,0  TERMINATION STEP,
   *1)
40  IF(FCF.LT.1.E-02)FCF=1.
   IF(MMIN.GT.1.E-08)IMAX=IMAX+1
   WRITE(6,2005)FCF
   2005 FORMAT(1H,13X,0INITIAL PRESSURE CORRECTION FACTOR =,0F7.4)
   SUMT=SUMT+.1
   XCPB(1)=XCPB(2)=0.0
   XCPB(3)=CGL
   WRITE(6,2006)XCPB(1),XCPB(2),XCPB(3)
   2006 FORMAT(1H,19X,0CENTROIDE COORDINATES,0F3(2X,16.5))
50  C.....CONSTANT VELOCITY
   IF(ICON.EQ.0)GO TO 30
   WRITE(6,2007)DM
   WRITE(6,2008)ALPHA
   WRITE(6,2009)ANG88
   2007 FORMAT(1H,38X,0INCREMENT IN DEPTH,0F10.7)
   2008 FORMAT(1H,42X,0ANGLE OF ATTACK,0F10.2)
   2009 FORMAT(1H,43X,0YAW ANGLE,0F7.2)

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34 READ(5,1002)NCW,CMT(1),I=1,NCW)
35 WRITE(5,2022)(CMT(I),I=1,NCW)
36 NVP=1
37 VEX(I)=SIN(ANGBR/CONVR)*VENTRY
38 VEZ(I)=-COS(ANGBR/CONVR)*COS((ANG-ALPHA)/CONVR)*VENTRY
39 VY(I)=0.0
40 DY(I)=-DM/(VEZ(I)*CMT(I))
41 CMT(I)=CMT(I)
42 GO TO 40
43 C.....VARIABLE ENTRY VELOCITY
44 2022 FORMAT(1H0,4X,15HEFFING FACTORS/(4X,F10.5))
45 C.....READ IN VELOCITY HISTORY
46 30 CONTINUE
47 NCW=1
48 READ(5,1002)NVP
49 WRITE(6,2006)
50 DO 10 I=1,NVP
51 REA(5,1001)VEX(I),VEY(I),VEZ(I),WX(I),CW(I),DT(I)
52 WRITE(6,2007)I,VEX(I),VEY(I),VEZ(I),WX(I),CMT(I),DT(I)
53 DY(I)=-DT(I)/CMT(I)*VEZ(I)
54 10 CONTINUE
55 2007 FORMAT(1H ,25X,I5,3F10.4,3F10.1,2F10.0,
56 1H*)
57 2006 FORMAT(1H0,27X,*NO*,7X,*VX*,8X,*VY*,8X,*VZ*,8X,*WX*,8X,*CMT*,8X,
58 1H*)
59 C.....DEFINE CONDITIONS FOR EACH STEP
60 40 NVP=NVP+1
61 DO 20 I=NVP+1,50
62 VEX(I)=VEX(NVP)
63 VEY(I)=VEY(NVP)
64 VEZ(I)=VEZ(NVP)
65 WX(I)=WX(NVP)
66 CMT(I)=CMT(NVP)
67 DT(I)=DT(NVP)
68 DY(I)=DT(I)*(1.+EPS)
69 GRID OPTIONS
70 READ(5,1002)N
71 IGRID(I)=N
72 WRITE(6,1006)
73 DO 70 I=1,N
74 I1=I+1
75 IGRID(I1)=1
76 READ(5,1000)GRID,GRID2,GRID3
77 IF (GRID.EQ.4)NOGIV)IGRID(I1)=2
78 IF (GRID.EQ.4)MLIST)IGRID(I1)=3
79 WRITE(6,1005)GRID,GRID2,GRID3
80 70 CONTINUE
81 1005 FORMAT(1H ,40X,3A4)
82 1996 FORMAT(1H0,34X,26H*****GRID OPTIONS*****))
83 1008 FORMAT(12A4)
84 1001 FORMAT(8F10.0)
85 1002 FORMAT(15,5X,7F10.0/(8F10.0))
86 1003 FORMAT(15,5X,7F10.0)
87 1004 FORMAT(3F10.0,15)
88 END
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FTN 4.5-410

13/73 OPT=1

SUBROUTINE INOSTA

DIAGNOSIS OF PROBLEM

CARD NO. SEVERITY DETAILS

46	1	ICPB	ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
47	1	ICPB	ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
48	1	ICPB	ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
48	1	ICPB	ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.

PAGE 1

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FTN 4.5+410

CURROUTINE STANG 73/73 OPT=1

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1 SUBROUTINE STANG(MPT,MEL,ANG,X,XT,IN,XCOS,MIN,ZTC,V1)
2 DIMENSION (201,Z(20),X(31),XT(31),IN(41),XCOS(1))
3 C.....I(1)=NUMBER OF ELEMENTS IN THE ITH ROW. IF I(1)=0, THIS NUMBER
4 C.....IS COMPUTED TO OBTAIN APPROXIMATELY SQUARE ELEMENTS WHICH ARE A
5 C.....MULTIPLE OF I(1)-1.
6 MPT=MP*1
7 CONVR=57.29577951
8 PTE=IR0./CONVR
9 READ(5,1004)NROWS,IANG,ISUP
10 IANG=IANG+1
11 FORMAT(A15)
12 WRITE(6,2040)
13 FORMATT(1M0,50X,ANG,OID SIZE/IN *4X,IMP*11X,INZ*4X,6X,MUSER)
14 SINE=SIN(IANG/CONVR)
15 COSF=COS(IANG/CONVR)
16 X(1)=Z(1)=0.0
17 MPT=NROWS+1
18 MLR=0
19 DO 18 I=2,NPWP
20 READ(5,1001)R(1R),Z(1R),I(1R)
21 WRITE(6,2041)R(1R),Z(1R),I(1R)
22 IF (I(1R).LT.6) MLR=1
23 I(1R-1)=IARS(I(1R),1)
24 IF (MLR.EQ.1) GO TO 8
25 IF (MPT1.ME.1) GO TO 8
26 ZML=Z(1R)*SINE-R(1R)*COSF
27 IF (MLR.EC.-ZTC) GO TO 8
28 ZTC=-ZML
29 YI=Z(1R)*COSF-R(1R)*SINE
30 CONTINUE
31 I(1)=3*(IANG+1)
32 FORMATT(2F10.0,15)
33 FORMATT(2F10.0,15)
34 DO 10 I=1,NROWS
35 IF (I(1).GT.0) GO TO 15
36 A/G=IR(1)*R(1)/Z
37 SL=SQRT((R(1)-Z(1))**2+(Z(1)-Z(1))**2)
38 X=XDIE*AVG/SL
39 I(1)=X*XIANG
40 CONTINUE
41 I(1)=I(1)-1
42 XML=I(1)-1
43 NCO=2
44 IF (I(1).EQ.1) GO TO 16
45 IF (I(1).EQ.1) GO TO 16
46 NCO=1
47 CONTINUE
48 DO 48 JK=NCO,2
49 Z=Z(1)-JK-1
50 R=R(1)-JK-1
51 DO 30 K=1,1,M
52 X=X-1
53 AN=PIE*H/XML*XIANG
54 MPT=MPT+1
55 X(3,MPT)=Z
56 X(2,MPT)=-COS(AN)*RR
57 X(1,MPT)=SIN(AN)*RR

```


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SUBROUTINE STANG 73/73 OPT=1

```

30 CONTINUE
40 CONTINUE
10 CONTINUE
  SINE=SIN(ANG*PIE/180.)
  COSE=COS(ANG*PIE/180.)
  DO 20 I=NP1,NPT
    XT(3,I)=X(3,I)*SINE-X(2,I)*COSE*ZTC-MMIN
    XT(2,I)=X(3,I)*COSE+X(2,I)*SINE-YT
    XT(1,I)=X(1,I)
20 CONTINUE
  IF(NPT1.NE.1)GO TO 52
  GZ= XCP8(3)*SINE-XCP8(2)*COSE*ZTC-MMIN
  GY=XCP8(3)*COSE+XCP8(2)*SINE-YT
  XCP8(3)=GZ
  XCP8(2)=GY
52 CONTINUE
  IF(IISUP.EQ.1)EC TO 51
  IM1(1)=1
  IM2(1)=2
  IM3(1)=3
  IM4(1)=4
  NEL=NEL+1
  IF(IANG.EQ.0)GO TO 51
  IM1(2)=7
  IM2(2)=4
  IM3(2)=5
  IM4(2)=6
  NEL=NEL+1
85 SUM=NP1
  DO 50 K=2,NROWS
    SUM=SUM+IN(K-1)*1
    IF(IWK(K).NE.IWK(K-1))SUM=SUM+IN(K)*1
    SUM=SUM-IN(K)-1
    IWK=IWK(K)
    DO 50 I=1,IWK
      NEL=NEL+1
      IM1(NEL)=SUM+I-1
      IM2(NEL)=SUM+I
      IM3(NEL)=SUM+I
      IM4(NEL)=SUM+I-1
50 RETURN
END

```

STANG 56
STANG 57
STANG 58
STANG 59
STANG 60
STANG 61
STANG 62
STANG 63
STANG 64
STANG 65
STANG 66
STANG 67
STANG 68
STANG 69
STANG 70
STANG 71
STANG 72
STANG 73
STANG 74
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STANG 80
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STANG 84
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STANG 87
STANG 88
STANG 89
STANG 90

CARD NO.	SEVERITY	DETAILS	DIAGNOSIS OF PROBLEM
69	I	XCP8	ARRAY REFERENCE OUTSIDE DIMENSION ROUNDS.
69	I	XCP8	ARRAY REFERENCE OUTSIDE DIMENSION ROUNDS.
70	I	XCP8	ARRAY REFERENCE OUTSIDE DIMENSION ROUNDS.
70	I	XCP8	ARRAY REFERENCE OUTSIDE DIMENSION ROUNDS.
71	I	XCP8	ARRAY REFERENCE OUTSIDE DIMENSION ROUNDS.
71	I	XCP8	ARRAY REFERENCE OUTSIDE DIMENSION ROUNDS.
72	I	XCP8	ARRAY REFERENCE OUTSIDE DIMENSION ROUNDS.
72	I	XCP8	ARRAY REFERENCE OUTSIDE DIMENSION ROUNDS.
73	I	IN	ARRAY REFERENCE OUTSIDE DIMENSION ROUNDS.
73	I	IN	ARRAY REFERENCE OUTSIDE DIMENSION ROUNDS.
73	I	IN	ARRAY REFERENCE OUTSIDE DIMENSION ROUNDS.

SUBROUTINE STANG
 94 MR. SEVERITY DETATLS
 1 IN
 73/73 OPT=1
 DIAGNOSIS OF PROBLEM
 ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
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```

SUBROUTINE OGIVG 73/73 QFT=1
1  SUBROUTINE OGIVG(NPT,MEL,ANG,X,XT,IN,XCPB,MWIN,ZTC,YTC)
   DIMENSION A(3,1),ATT(3,1),XCPB(3),IN(4,1),M(50),IN(50),B(150)
   C.....SUBROUTINE APPLICABLE TO AXISYMMETRIC BODIES WITH A POINTED NOSE.
   C.....USER PROVIDES GRID HEIGHT ON THE WINDWARD RAY OF THE BODY.
   C.....BODY ORIENTATION AND NUMBER OF ELEMENTS IN EACH ROW ARE ALSO
   C.....SPECIFIED. NOTE- BODY SLOPE AT EACH RING MUST BE GREATER THAN
   C.....THAT OF THE BODY ORIENTATION.
   COMMON/RAD/MBODY,R(150),Z(150)
   NPT=NPT+1
   IF(MPT.LE.0.1)ZTC=YTC=0.0
   C/MVR=57.29577951
   SINE=SIN(ANG/CONVR)
   COSF=COS(ANG/CONVR)
   C.....READ IN DATA
   READ(15,1000)MROWS,MBODY,IANG
   MROWS=MROWS+1
   IANG=IANG+1
   1000 FORMAT(4I5)
   WRITE(6,2000)IANG
   2000 FORMAT(1H0,40X,'SYMMETRY = ',I5)
   READ(15,1001)(R(I),Z(I),I=1,MBODY)
   1001 FORMAT(2F10.6)
   WRITE(6,2001)
   2001 FORMAT(1H ,50X,'BODY PROFILE',1H ,40X,1MR,11X,1HZ)
   M1=6,2002)R(1),Z(1),I=1,MBODY)
   2002 FORMAT(1H ,37X,F10.6,4X,F10.6)
   READ(15,1002)(M(1),B(1),IN(1),I=2,MROWS)
   1002 FORMAT(2F10.6,I5)
   WRITE(6,2003)
   2003 FORMAT(1H ,50X,'GRID SIZE',1H ,40X,1MR,11X,1MB,4X,'NUMBER')
   WRITE(6,2004)(M(1),B(1),IN(1),I=2,MROWS)
   2004 FORMAT(1H ,37X,F10.6,4X,F10.6,4X,I5)
   C.....CONSTRUCT NODES
   I=MBODY
   R(1,1)=1000.
   Z(1,1)=Z(1),Z(1)-Z(1-1))*(R(1,1)-R(1-1))/(R(1,1)-R(1-1))
   M(1,1)=M(2)/1000.
   W(1,1)=W(2)
   R(1,1)=90.
   SGNP=1.
   API=RP2=0.0
   DO 10 I=1,MROWS
   TANG=TAN(90.-B(1))/CONVR
   XW=W(1)
   YW=W(1)+1
   YD=RADIUS*(M(1))
   ZD=M(1)
   SUN=1.
   PG=ZD
   ENR=ERR=1-E*08
   DT=100.*XANG/(CONVR*XW)
   DO 10 K=1,1WK
   OUG=RG/10.
   MPT=NPT+1
   XFR=R-1
   ?L=0
   ?LP=0

```

DEC06 67
NOV23 1
NOV23 2
NOV23 3
NOV23 4
NOV23 5
NOV23 6
NOV23 7
NOV23 1
NOV23 9
NOV23 10
NOV23 11
NOV23 12
NOV23 13
NOV23 14
NOV23 15
NOV23 16
NOV23 17
NOV23 18
NOV23 19
NOV23 20
NOV23 21
NOV23 22
NOV23 23
NOV23 24
NOV23 25
NOV23 26
NOV23 27
NOV23 28
NOV23 29
NOV23 30
NOV23 31
NOV23 32
NOV23 33
NOV23 35
NOV23 36
NOV23 37
NOV23 38
NOV23 39
NOV23 40
NOV23 42
NOV23 43
NOV23 44
NOV23 45
NOV23 46
NOV23 47
NOV23 48
NOV23 49
NOV23 50
NOV23 51
NOV23 52
NOV23 53
NOV23 54
NOV23 55
NOV23 57

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SUBROUTINE O61G 73/73 OPT=1

```

40      T=UT*WK
      CUST=COS(T)
      14  AG=PG*SGN*DRG
      16  IC=IC+1
      IF (IC.GT.100) STOP
      Y=PG*COST
      ZZ=ZO*(Y-YO)*TANH
      EM=RAIDUS*(Z1-AG
      IF (ARS(ERR).LT.PG/10000.1GO TO 15
      SGN=1-
      IF (ERR.LT.0.01SGN=-1.
      AP2=AP1
      EM=EM*ERR1
      AP1=PG
      F=1=ERR
      IF (IC.EQ.11GO TO 14
      IF (1TP.EQ.11GO TO 17
      IF (ERR1*ERR2.GT.0.01GO TO 14
      17  ITP=1
      AG=AP1-(AP2-RP1)*ERR1/(ERR2-ERR1)
      GO TO 16
      15  X(1,NPT)=AG*SIN(T)
      X(2,NPT)=Y
      10  X(3,NPT)=ZZ
      DO 21 I=NPT1,NPT
      XT(I,1)=X(I,1)*SINE-X(2,1)*COSE*ZTC-HMIN
      XT(I,1)=X(I,1)*COSE*X(2,1)*SINE-VTC
      XT(I,1)=X(I,1)
      21  CONTINUE
      IF (NPT1.NE.11GO TO 52
      GZ=XCPB(3)*SINE-XCPB(2)*COSE*ZTC-HMIN
      GY=XCPB(3)*COSE-XCPB(2)*SINE-VTC
      XCPB(3)=GZ
      XCPB(2)=GY
      52  CONTINUE
      SUM=NPT1
      DO 50 K=2,NPOWS
      SUM=SUM*(WK-K+1)
      IF (11WK).NE.1*(K-1)) SUM=SUM*(K+1)
      SUM=SUM-1*(K-1)
      TWK=1*(WK)
      DO 50 I=1,WK
      NEL=NEL+1
      IN(1,NEL)=SUM*I-1
      IN(2,NEL)=SUM*I
      IN(3,NEL)=SUM*I
      IN(4,NEL)=SUM*I-1
      50  IN(4,NEL)=SUM*I-1
      RETURN
      END

```

FUNCTION	RADIUS	73/73	OPT=1	FTN 4.5.410	7-701/17. 11-07.10	PAGE	1
1					MOV23 111		
					MOV23 112		
					MOV23 113		
					MOV23 114		
5					MOV23 115		
					MOV23 116		
					MOV23 117		
					MOV24 10		
					MOV23 118		
10					MOV23 119		
					OS1V6 3		

```

FUNCTION RADIUS(H)
COMMON/RAD/M800Y,R(50),Z(50)
RADIUS=0.0
DO 19 I=1,M800Y
  FAC=(H-Z(I))*(H-Z(I+1))
  IF (FAC.GT.0.0) GO TO 10
  RADIUS=R(I)*(R(I+1)-R(I))*(H-Z(I))/(Z(I+1)-Z(I))
RETURN
10 CONTINUE
RETURN
END

```

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SUBROUTINE LISTG 73/73 OPT=1

```

1  SUBROUTINE LISTG(NPT,NEL,ANG,X,XT,IN,XCP8,HMIN,ZTC,YTC)
   DIMENSION X(3,1),XT(3,1),IN(4,1),XCP8(1)
   C.....ARBITRARY BODY GRID SUBROUTINE
   C.....COORDINATES OF ALL NODES MUST BE PROVIDED
   C.....NODE GROUPS COMPOSING EACH ELEMENT MUST BE INPUT
   CONV=57.29577951
   NPT1=NPT+1
   READ(5,1000)NP,NE
   1000 FORMAT(I5)
   C.....READ NODE POINTS AND CALCULATE XT
   SIN=SI(ANG/CONV)
   COS=COS(ANG/CONV)
   DO 10 I=1,NP
     NPT1=NPT+1
     1001 FORMAT(3F10.0,I5)
     READ(5,1001)X(1,NPT1),X(2,NPT1),X(3,NPT1),MLD
     XT(1,NPT1)=X(1,NPT1)
     XT(2,NPT1)=X(2,NPT1)*COS+X(3,NPT1)*SIN
     XT(3,NPT1)=X(3,NPT1)*SIN-X(2,NPT1)*COS
     IF (MLD.GT.0) GO TO 10
     IF (NPT1.NE.1) GO TO 10
     IF (XT(3,1).GT.-ZTC) GO TO 10
     YTC=XT(2,1)
     ZTC=-XT(3,1)
     10 CONTINUE
     DO 15 I=NPT1,NPT
       XT(3,I)=XT(3,1)+ZTC-HMIN
     15 XT(2,I)=XT(2,1)-YTC
       IF (NPT1.NE.1) GO TO 52
       GZ=XCP8(3)*SIN-XCP8(2)*COS+ZTC-HMIN
       GY=XCP8(3)*COS+XCP8(2)*SIN-YTC
       XCP8(3)=GZ
       XCP8(2)=GY
     52 CONTINUE
   C.....READ IN ELEMENTS
   DO 20 I=1,NEL
     NEL=NEL+1
     20 READ(5,1000)IN(1,NEL),IN(2,NEL),IN(3,NEL),IN(4,NEL)
     RETURN
   END

```

CARD NO. SEVERITY DETAILS DIAGNOSIS OF PROBLEM

```

30 1 XCP8 ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
30 1 XCP8 ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
31 1 XCP8 ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
31 1 XCP8 ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
32 1 XCP8 ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
33 1 XCP8 ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.

```

SUBROUTINE GRID	73/73	OPT=1	FIN 4.5+10	77/01/17. 11.07.10	PAGE 1
1	SUBROUTINE GRID(MPT,NEL,X,XT,IN,PHIO,XC,ACHECK,NMLD)				DEC14 11
	DIMENSION X(3,1),XT(3,1),IN(4,1),XC(3,1),PHIO(2,1)				GRID 3
	C.....PRINT NODES				GRID 4
	WRITE(6,2006)				GRID 5
5	2006 FORMAT(1M0,13X,5NMODE,10X,1M4,8X,1M7,9X,2MXP,8X,2MYP,8X,				GRID 6
	2MXP)				GRID 7
	DO 5 I=1,MPT				GRID 8
	5 WRITE(6,2007)I,(X(J,I),J=1,3),(XT(J,I),J=1,3)				GRID 9
	2007 FORMAT(1M,10X,15,5X,6(2X,F8.4))				GRID 10
	WRITE(6,2008)				GRID 11
10	2008 FORMAT(1M0,15X,7MELEMENT,7X,1M1,9X,1M2,9X,1M3,9X,1M4,7X,2MXC,7X,				MOV03 26
	2MVC,7X,2MVC,7X,2MVC,8X,2MVC,7X,4MAREA,1M)				MOV03 27
	CALL CENT(X,XC,IN,NEL,PHIO)				GRID 13
	C.....PRINT ELEMENT NODES, AREA AND CENTROIDS				GRID 14
15	ACHECK=0.0				MOV15 114
	DO 10 I=1,NEL				GRID 15
	IF(I.EQ,NMLD)WRITE(6,2010)				DEC14 12
	ACHECK=ACHECK+PHIO(2,I)				MOV15 115
	R=SQRT(XC(1,I)**2+XC(2,I)**2)				MOV03 28
	ANGLE=57.2957795*ATAN2(XC(1,I),XC(2,I))				MOV03 4
20	10 WRITE(6,2009)I,(IN(J,I),J=1,4),(XC(J,I),J=1,3),R,ANGLE,PHIO(2,I)				MOV03 29
	2009 FORMAT(1M,10X,5(5X,15),4(2X,F8.5),2X,F8.3,E12.4)				MOV03 30
	ACHECK=SQRT(ACHECK*ACHECK)/1000.				MOV15 116
	RETURN				GRID 20
25	2010 FORMAT(1M0,30X,4NO LOAD ELEMENTS=)				DEC14 13
	END				GRID 21

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73/73 OPT=1

SUBROUTINE ADVN

```

1 SUBROUTINE ADVN(XT,VEZ,VEX,VEX,CWT,CWT,WA,ANG,XCPB,IS,MPT,DT,
  *DDZ,MMAX)
2
3 C-----SUBROUTINE MOVES MODES FORWARD IN TIME
4 C-----THE SPLASH HEIGHT, DELTA H=(CWT(1)-1.) IS BASED ON THE DELTA
5 C-----H OF THE DEEPEST POINT.
6
7 DIMENSION XT(3,1),VEZ(1),VEX(1),CWT(1),WA(1),XCPB(1),DT(1)
8 CONVR=57.29577951
9
10 DOT=DT/(1S)
11 CWT=CWT/(1S)
12 VSA=VEX/(1S)
13 VSY=VEY/(1S)
14 VSZ=VEZ/(1S)
15 ZDEEP=1000.
16
17 DG=WX/(1S)*DDT
18 ANG=ANG*DG
19 SIND=SIN(DG/CONVR)
20 COSO=COS(DG/CONVR)
21 DO 10 I=1,MPT
22 ZP=XT(3,I)-XCPB(3)
23 YP=XT(2,I)-XCPB(2)
24 DZ=DOT*VSZ-ZP*(1.-COSO)*YP*SIND
25 XT(1,I)=XT(1,I)+DZ
26 ZCH=XT(1,I)
27
28 XT(2,I)=XT(2,I)+VSY*DDT-YP*(1.-COSO)-ZP*SIND
29 XT(1,I)=XT(1,I)+DOT*VSA
30 IF(ZCH.GT.ZDEEP)GO TO 10
31 ZDEEP=ZCH
32 DDZ=DZ*(1.-CWT)
33 MMAX=DDZ-XT(3,I)
34
35 DO 15 I=1,MPT
36 XT(3,I)=XT(3,I)+DDZ
37 XCPB(3)=XCPB(3)+VSZ*DDT-DDZ
38 XCPB(2)=XCPB(2)+VSY*DDT
39 XCPB(1)=XCPB(1)+VSA*DDT
40 RETURN
41 END

```

CAVITY NO. SEVERITY DETAILS DIAGNOSIS OF PROBLEM

19	I	XCPB	ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
20	I	XCPB	ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
34	I	XCPB	ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
34	I	XCPB	ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
35	I	XCPB	ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
35	I	XCPB	ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.


```

1  SUBROUTINE CREL(X,IM,IT,IC,IM,ITEM,IMP,ANG,IMP,XT,XCPB,CGL,
*CHECK)
DIMENSION X(3,1),IM(4,1),IT(4,1),IO(1),IM(1),I(A),XT(3,1),XCPB(3)
CONVR=57.29577951
IEN=0
IMP=IMP1
DO 5 K=1,NEL
ITOT=0
SUM=X(1,IM(1,K))+X(1,IM(2,K))+X(1,IM(3,K))+X(1,IM(4,K))
C.....COUNT NUMBER OF POINT BELOW SURFACE
DO 10 J=1,4
I(J)=0
I1=IN(J,K)
IF(XT(3,I1)-GT,0.0)I(J)=1
IF(XT(3,I1)-GT,-ACHECK)ITOTC=ITOTC+1
IF(I(J).EQ.0)IF=J
IF(I(J).EQ.1)JF=J
10 ITOT=ITOT+I(J)
C.....IF ALL POINTS ARE ABOVE WATER SURFACE DISCARD ELEMENT.
IF(ITOT.EQ.4)GO TO 5
IF(ITOTC.EQ.4)GO TO 5
ITEM=ITEM+1
IM(ITEM)=K
IO(ITEM)=K
DO 15 L=1,4
15 IT(L,ITEM)=IM(L,K)
C.....IF ALL POINTS ARE BELOW THE WATER USE ELEMENTS AS IS.
IF(ITOT.EQ.0)GO TO 5
IM(ITEM)=1
C.....DETERMINE NODES BOUNDING ELEMENT SIDES INTERSECTED BY THE SURFACE.
DO 25 L=1,4
LM=L-1
IF(L.EQ.4)LM=1
IF(IT(L).I(LM).NE.1)GO TO 25
IG=L
IG=L
IF(IT(L).EQ.0)GO TO 30
IG=L
18=L
18=L
30 IG=INT(IG,K)
I18=INT(I18,K)
IMP=IMP+1
XT(3,IMP)=0.0
RATIO=XT(3,I18)/(XT(3,I18)-XT(3,IG))
XT(2,IMP)=XT(2,I18)+RATIO*(XT(2,I18)-XT(2,IG))
XT(1,IMP)=XT(1,I18)+RATIO*(XT(1,I18)-XT(1,IG))
IT(18,ITEM)=IMP
25 CONTINUE
C.....IF TWO NODES ARE SUBMERGED NEW ELEMENT COMPLETE.
IF(ITOT.EQ.2)GO TO 5
IF(ITOT.EQ.1)GO TO 6
C.....ONLY ONE NODE SUBMERGED
I1= IF=1
I2=IF-1
IF(I1.EQ.5)I1=1
IF(I2.EQ.0)I2=4

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SUBROUTINE CREL 73/73 OPT=1

```

60      M1=I(IPI, IEM)
        M2=I(IP2, IEM)
        IMP=IMP+1
        DO 9 JS=1,3
          XT(JS,IMP)=(XT(JS,M1)+XT(JS,M2))/2.
9      CONTINUE
        IP3=IP1+1
        IF(IP3.EQ.5)IP3=1
        IT(IP3, IEM)=IMP
        GO TO 5
65      C.....THREE SUBMERGED POINTS
        6 JF1=JF+1
          IF(JF1.EQ.5)JF1=1
          JF2=JF1+1
          IF(JF2.EQ.5)JF2=1
          JF3=JF2+1
          IF(JF3.EQ.5)JF3=1
          IF(SUM.LT.0.0)GO TO 45
          IT(JF, IEM)=IMP-1
          IT(JF1, IEM)=IMP+1
          IEM=IEM+1
          IT(JF, IEM)=IMP
          IT(JF1, IEM)=IMP(JF1,K)
          IT(JF2, IEM)=IMP+1
          IT(JF3, IEM)=IMP-1
          IP1=IMP(JF1,K)
          IP2=IMP(JF2,K)
          GO TO 50
70      45 IT(JF, IEM)=IMP
          IT(JF3, IEM)=IMP+1
          IEM=IEM+1
          IT(JF, IEM)=IMP
          IT(JF1, IEM)=IMP+1
          IT(JF2, IEM)=IMP-1
          IT(JF3, IEM)=IMP-1
          IP1=IMP(JF1,K)
          IP2=IMP(JF2,K)
          IP3=IMP(JF3,K)
          IMP=IMP+1
          IQ(IEM)=K
          IT(IEM)=2
          DO 8 LK=1,3
            XT(LK,IMP)=(XT(LK,IP1)+XT(LK,IP2))/2.
8      CONTINUE
          IF(LF.WE.1)GO TO 5
          DO 41 JGG=1,3
            XLK=XT(JGG,IMP-1)
            XT(JGG,IMP-1)=XT(JGG,IMP-2)
            XT(JGG,IMP-2)=XLK
41      CONTINUE
        5      C.....TRANSFORM GENERATED NODES TO WATER COORDINATES.
          IF(MPT.EQ.IMP)RETURN
          SINE=SIN(ANG/CONVR)
          COSECOS=COS(ANG/CONVR)
          MPT=MPT+1
          DO 20 K=MPT,IMP
            ZPT=XT(13,K)-XCP8(13)

```

CREL 50
 CREL 51
 CREL 52
 CREL 53
 CREL 54
 CREL 55
 CREL 56
 CREL 57
 CREL 58
 CREL 59
 MOV11 50
 CREL 60
 CREL 61
 CREL 62
 CREL 63
 CREL 64
 CREL 65
 MOV11 59
 CREL 66
 CREL 67
 CREL 68
 CREL 69
 CREL 70
 CREL 71
 CREL 72
 CREL 73
 CREL 74
 MOV11 60
 MOV11 61
 MOV11 62
 MOV11 63
 MOV11 64
 MOV11 65
 MOV11 66
 MOV11 67
 MOV11 68
 MOV11 69
 MOV11 70
 CREL 75
 CREL 76
 CREL 77
 CREL 78
 CREL 79
 CREL 80
 CREL 81
 CREL 82
 CREL 83
 CREL 84
 CREL 85
 CREL 86
 MOV11 71
 DEC15 3
 CREL 87
 CREL 88
 CREL 89
 CREL 90
 MOV03 51

SUBROUTINE	CREL	73/73	OPT=1	FTN 4.5+410	77/01/17. 11.07.10	PAGE
115					MOV03 52	
					MOV02 11	
					CREL 94	
					CREL 95	
					CREL 96	
					CREL 97	
120						

```

YPT=XT(12,K)-XCP8(12)
X(13,K)=ZPT*SINE+YPT*COSE+CG1
X(12,K)=-ZPT*COSE+YPT*SINE
20 X(11,K)=XT(11,K)
RETURN
END

```

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FTN 4.5-410

73/73 OPT=1

SUBROUTINE MAN

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1 SUBROUTINE MAN(X,IT,IT,IC,XCP,ICM,ANG,PHI0,IO,XCP8,CGL,E)
  DIMENSION X(3,1),IT(4,1),XT(3,1),XCP(3,1),E(3,3,1),F(3)
  CONVR=57.29577951
  SINE=SIN(ANG/CONVR)
  COSE=COS(ANG/CONVR)
  CALL CENT(XT,XCP,IT,ICM,PHI0)
  DO 10 K=1,ITEM
    I1=IT(1,K)
    I2=IT(2,K)
    I3=IT(3,K)
    I4=IT(4,K)
    C.....TRANSFORM CENTROID TO BODY COORDINATES
    ZPT=XCP(3,K)-XCP8(3)
    YPT=XCP(2,K)-XCP8(2)
    XC(1,K)=XCP(1,K)
    XC(2,K)=-ZPT*COSE+YPT*SINE
    XC(3,K)=ZPT*SINE+YPT*COSE+CGL
    DO 20 L=1,3
      F(L)=XT(L,I3)-XT(L,I1)
    20 G(L)=XT(L,I2)-XT(L,I4)
    DEL1=SQRT(F(1)*F(1)+F(2)*F(2)+F(3)*F(3))
    DEL2=SQRT(G(1)*G(1)+G(2)*G(2)+G(3)*G(3))
    DO 25 L=1,3
      E(L,1,K)=F(L)/DEL1
      E(L,2,K)=G(L)/DEL2
    25 F(1)=E(2,1,K)*E(3,2,K)-E(3,1,K)*E(2,2,K)
      F(2)=E(3,1,K)*E(1,2,K)-E(1,1,K)*E(3,2,K)
      F(3)=E(1,1,K)*E(2,2,K)-E(1,2,K)*E(2,1,K)
      DEL=SQRT(F(1)*F(1)+F(2)*F(2)+F(3)*F(3))
      DO 30 L=1,3
    30 F(L,1,K)=F(L)/DEL
      F(L,2,K)=E(2,1,K)*E(3,1,K)-E(2,1,K)*E(3,3,K)
      F(L,3,K)=E(1,1,K)*E(3,3,K)-E(1,3,K)*E(3,1,K)
      F(3,2,K)=E(1,3,K)*E(2,1,K)-E(1,1,K)*E(2,3,K)
    10 CONTINUE
      RETURN
    END

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1  SUBROUTINE ELEMS1(IMP,NPT,IT,IE4,IG,IM,X,XT,XC,XCP,E,PHI0,ISTEP,M)
   DIMENSION X(3,1),XT(3,1),IT(4,1),PHI0(2,1),XC(3,1),XCP(3,1),
   *IG(1),IM(1),E(1,3,1)
   WRITE(6,2030)ISTEP,M
5  2030 FORMAT(1M0,30X,5MSTEP,15,2X,6HDEPTH,6F10.7)
   2010 FORMAT(1M0,10X,15HGENERATED MODES)
   NPT1=NPT-1
   WRITE(6,2010)
   WRITE(6,2006)
10  DO 25 I=NPT1,IMP
   WRITE(6,2007)I,(X(J,I),J=1,3),(XT(J,I),J=1,3)
   25  WRITE(6,2011)
   WRITE(6,2008)
   2011 FORMAT(1M0,10X,12HRUN ELEMENTS)
15  DO 30 I=1,IE4
   30  WRITE(6,2009)I,(IT(J,I),J=1,4)
   2019 FORMAT(1M1,15X,18HELEMENT STATISTICS)
   DO 35 I=1,IEM
   35  IF(PHI0(I,IG(I))-67.4-0.060 TO 35
   IF(IM(I),EQ,0)PHI0(I,IG(I))=1.
   WRITE(6,2012)I,IG(I),IM(I),XC(J,I),J=1,3),(XCP(J,I),J=1,3)
20  2012 FORMAT(1M0,12HELEMENT NO.,15,5X,14HREFERENCE NO.,15,5X,
   21HMODIFICATION CODE,15/1M,10X,12HCENTROIDE X,3(F8.4,2X),2HXP,
   33(2X,F8.4))
25  WRITE(6,2013)
   2013 FORMAT(1M0,5X,6HCORNER,7X,4HMODE,9X,1M,9X,1M,9X,1M,2,9X,2HXP,
   29X,2HYP,8X,2H2P)
   DO 45 K=1,4
   45  IF(IT(K,I))
   45  WRITE(6,2016)K,11,IG(K,I),K1=1,3),(XT(K2,I),K2=1,3)
   2016 FORMAT(1M,5X,2115,5X),6(F8.4,2X)
   WRITE(6,2017)PHI0(2,1)
30  2017 FORMAT(1M0,5X,6HVECTOR,8X,1M,8X,1M,2,9X,1M,3,7HAREA =,6F12.7)
   DO 50 K=1,3
   50  WRITE(6,2018)K,(E(JR,K,I),JR=1,3)
35  2018 FORMAT(1M,8X,15,3(2X,F8.4))
   35  CONTINUE
   RETURN
40  2006 FORMAT(1M0,13X,5HMODE,10X,1M,8X,1M,9X,1M,2,9X,2HXP,8X,2HYP,8X,
   *2H2P)
   2007 FORMAT(1M,10X,15,5X,6(2X,F8.4))
45  2008 FORMAT(1M0,15X,7HELEMENT,9X,1M,9X,1M,2,9X,1M,3,9X,1M,4/1M)
   2009 FORMAT(1M,10X,5(5X,15),4(2X,F8.5),2X,F8.3)
   END

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77/01/17. 11.07.16

FTN 4.5*410

SUBROUTINE VNORM 73/73 OPT=1

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1  SUBROUTINE VNORM(VZ,VY,VX,VNO,E,IEM,ISTEP,XCP,XCPB,IPRINT)
   DIMENSION VZ(1),VY(1),VX(1),VNO(1),VND(1),E(3,3),XCP(3,1),
   *XCPB(1)
   CONVR=57.29577951
   VZ=(VZ(ISTEP)+VZ(IISTEP+1))/2.
   VY=(VY(ISTEP)+VY(IISTEP+1))/2.
   VX=(VX(ISTEP)+VX(IISTEP+1))/2.
   VXX=(VX(ISTEP)+VX(IISTEP+1))/2.
   IF(IIPRINT.EQ.1)WRITE(6,20001)VX,VY,VZ,VXX
   DO 5 I=1,IE
   VZC=VZ+VXX*(XCP(2,I)-XCPB(2))/CONVR
   VYC=VY+VXX*(XCP(3,I)-XCPB(3))/CONVR
   5 VNO(I)=VZC*F(3,3,I)+VYC*E(2,3,I)+VX*E(1,3,I)
   RETURN
15  2000 FORMAT(1H,10X,VX = *F10.3*, VY = *F10.3*, VZ = *F10.3*,
   ** VX = *F10.2)
   END

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FTN 4.5-410

SUBROUTINE AMAT 73/73 OPT=1

```

1  SUBROUTINE AMAT(XCP,XT,IT,IEW,A,AY,AX,PHI,VMO,F,IPMI)
   DIMENSION XCP(3,1),XT(3,1),PHI(1),VMO(1),A(1),AY(1),
   *IT(4,1),E(3,3,1)
5  DIMENSION F(3),XI(3,4),XPI(3),C(4),D(4),CS(4),Q(4),CR(4),R(4),
   2S(2,4),XJ(4),V(3),VI(3),X(3)
   DIMENSION XCPI(3),EI(3,3),ATI(3,4)
   PIE=3.14159265
   IXAN=3-IPMI
   IPMC=2-IPMI
   CONVP=100./PIE
   DO 5 J=1,IEW
   DO 2 I=1,IEW
2  A(I)=AX(I),AY(I)=PHI(I)=0.0
   DO 41 I=1,3
   XCPI(I)=XCP(I,J)
   DO 42 K=1,3
42  E(I,K)=E(K,I,J)
   DO 41 L=1,4
41  XT(I,L)=XT(I,IT(L,J))
   DO 6 IR=1,IXAN
   DO 7 IZ=1,2
7  F(IZ)=F(IZ,IR)
   C.....CALCULATE NODE LOCATION IN ELEMENT COORDINATES
   DO 11 L=1,4
   DO 10 K=1,3
10  F(K)=XT(I,K,L)-XCPI(I)
   DO 11 IR=1,3
11  XI(4,L)=F(1)*EI(1,IR)+F(2)*EI(2,IR)+F(3)*EI(3,IR)
   OSI=XI(1,3)-XI(1,1)
   DMU=XI(2,3)-XI(2,1)
   DSN=XI(2,2)-XI(2,4)
   XI(9)=DSI*DSN*5
   DCM2=DSI*DSI*DMU*DMU
   ML1=XI(1,2)-XI(1,4)+2*DSN*DSN
   IF(DCM2.LT.ML1)DCM2=ML1
   C1=XI(1,1)+XI(1,2)+XI(1,3)
   C2=XI(1,1)+XI(1,1)+XI(1,3)+XI(1,3)+XI(1,3)
   C3=XI(1,4)+C1
   C4=C3-XI(1,2)
   XI(20)=DSI/12*(XI(2,1)+XI(1,4)-XI(1,2)+C3+C2*(XI(2,2)-XI(2,4)))
   *XI(1,2)+XI(2,2)+C1-XI(1,4)+XI(2,4)+C4)
   C1=XI(2,1)+XI(2,4)+XI(2,1)+XI(2,1)+XI(2,4)
   C2=XI(2,1)+XI(2,2)+XI(2,2)+XI(2,1)+XI(2,2)
   C3=2*(XI(2,1)+XI(2,2)+XI(2,4))
   XI(1)=DSI/24*(C2-XI(1,4)+C1-2*(XI(1,2)+C2*(XI(1,1)+XI(1,3))+
   10SN+C3)
   C2=XI(2,2)+XI(2,4)
   C1=XI(2,1)+C2+2
   XI(2)=XI(20)/6*(C1-XI(2,1)+C2-XI(2,2)+XI(2,4))
   DO 27 K=1,4
   K1=K+1
   IF(K.EQ.4)K1=1
   D(K)=SQRT((XI(1,K1)-XI(1,K))**2+(XI(2,K1)-XI(2,K))**2)
   C(K)=(XI(1,K1)-XI(1,K))/D(K)
27  CS(K)=(XI(2,K1)-XI(2,K))/D(K)
   DO 45 I=1,ICM
45  C.....DETERMINE POINT AT WHICH VELOCITY IS INDUCED IN ELEMENT COORDINATE
   DO 15 K=1,3

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FTN 4.5-010

SUBROUTINE AMAT T3/T3 OPT=1

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15 X(K)=XCP(K,I)-XCP(K)
R02=X(1)*X(1)*X(2)*X(2)*X(3)*X(3)
IF(R02/DCH2.LE.16-.160 TO 70
    DO 21 K=1,3
21 X(K)=X(1)*X(1)*X(2)*X(2)*X(3)*X(3)*E(3,K,I)
R05=SQRT(R02)
PH=X100/R0
FAC=PH/R02
V(1)=X(1)*FAC
V(2)=X(2)*FAC
V(3)=X(3)*FAC
60 TO 71
70 CONTINUE
    DO 20 K=1,3
20 X(K)=X(1)*X(1)*X(2)*X(2)*X(3)*X(3)*E(3,K)
C.....CALCULATE INDUCED VELOCITIES
IF(R02/DCH2.LE.6)GO TO 72
C.....MULTIPOLE EXPANSION
R01=SQRT(R02)
R03=R01*R02
R05=R02*R03
R07=R05*R02
X=X/R01
Y=Y/R01
Z=Z/R01
X2=X*X
Y2=Y*Y
Z2=Z*Z
PP=YT2-ZZ2-4.*X2
QQ=X2+Z2-4.*Y2
W=-X/R03
WZ=-Y/R03
WZ=-Z/R03
WXX=-179.*X2)*R05
WXY=3.*X*Y)*R05
WY=100.*Y2)*R05
WXX=3.*X*(3.*X2)*R07
WXY=3.*X*Y)*R07
WY=3.*Y*(3.*Y2)*R07
WY=3.*Y*Z)*R07
WY=15.*X*Y)*R07
WY=3.*Z*Y)*R07
PH=X100/R01-.5*(X120*WXX+2.*X111*WXY+X102*WYY)
V(1)=-X100*W-5*(X120*WXX+2.*X111*WXY+X102*WYY)
V(2)=-X100*W-5*(X120*WXX+2.*X111*WXY+X102*WYY)
V(3)=-X100*W-5*(X120*WXX+2.*X111*WXY+X102*WYY)
60 TO 73
72 CONTINUE
C.....COMPLETE FORMULAS
    DO 25 K=1,6
25 K=K+1
IF(K.EQ.4)KI=1
S(1,K)=X(1)*X(1)*X(2)*X(2)*X(3)*X(3)*C(K)-X(2)*X(2)*X(3)*X(3)*C(K)
S(2,K)=X(1)*X(1)*X(2)*X(2)*X(3)*X(3)*C(K)-X(2)*X(2)*X(3)*X(3)*C(K)
CR(K)=(X(1)*X(1)*X(2)*X(2)*X(3)*X(3)*C(K)-X(2)*X(2)*X(3)*X(3)*C(K)

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FTN 4.5+10

73/73 OPT=1

SUBROUTINE AMAT

```

115 R(K)=SQRT((XP(1)-XI(1,K))**2+(XP(2)-XI(2,K))**2+XP(3)**2)
25 CONTINUE
V(1)=0.0
V(2)=0.0
V(3)=0.0
AZ=ABS(XP(3))
AS=-1.
IF(XP(3).GE.0.0)AS=1.
PH=0.9
DO 30 K=1,4
K1=K+1
IF(K.EQ.4)K1=1
O(K)=ALOG((R(K)*R(K1)+D(K))/(R(K)+R(K1)-D(K)))
XJ(K)=0.0
IF(CR(K).EQ.0.0)GO TO 61
FT=ABS(XP(3)/CR(K))
XJ(K)=ABS(CR(K))/CR(K)*(ATAN(FT*S(2,K)/R(K))-ATAN(FT*S(1,K)/
2R(K)))
61 CONTINUE
PH=PH-AZ*XJ(K)-CR(K)*Q(K)
V(1)=V(1)-CS(K)*Q(K)
V(2)=V(2)+C(K)*Q(K)
30 V(3)=V(3)-XJ(K)
DTH=2.*PIE
ICRT=0
DO 46 KU=1,4
46 CONTINUE
IF(CR(KU).GT.0.0)ICRT=1-ICRT
IF(ICRT.LT.4)DTH=0.0
PH=PH-AZ*DTH
V(3)=AS*(V(3)+DTH)
C-----TRANSFORM VELOCITY TO COORDINATE OF ELEMENT AT WHICH IT IS INDUCED
73 CONTINUE
V(1)=0.0
V(2)=0.0
V(3)=0.0
DO 35 K=1,3
DO 35 L=1,3
35 V(L)=V(K)+V(L)*EI(1,L)*EI(1,K,I)+EI(2,L)*EI(2,K,I)+EI(3,L)*
2E(3,K,I)
71 CONTINUE
BLK=(-1.)*IZ
A(1)=A(1)+V(3)*BLK
AY(1)=AY(1)+V(2)*BLK
AX(1)=AX(1)+V(1)*BLK
PHI(1)=PHI(1)+PH*BLK
45 CONTINUE
XCPI(3)=-XCPI(3)
DO 8 IU=1,4
8 XTI(3,IU)=-XTI(3,IU)
EI(3,1)=-EI(3,1)
EI(1,2)=-EI(1,2)
EI(2,2)=-EI(2,2)
EI(3,3)=-EI(3,3)
DO 22 IU=1,3
22 XBLAK=XTI(IU,2)
XTI(IU,2)=XTI(IU,4)

```

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SUBROUTINE AMAT 73/73 OPT=1

```

22 XTI(IU,4)=XRLAK
7 CONTINUE
IF (IPHC) 4,6
4 CONTINUE
XCP(1)=XCP(1)
DO 9 IU=1,4
9 XTI(1,IU)=XTI(1,IU)
EI(1,1)=EI(1,1)
EI(2,2)=EI(2,2)
EI(3,3)=EI(3,3)
EI(1,3)=EI(1,3)
DO 23 IU=1,3
XRLAK=XTI(IU,2)
XTI(IU,2)=XTI(IU,4)
23 XTI(IU,4)=XRLAK
6 CONTINUE
WRITE(16) (AK,K=1,IEM), (AX(K),K=1,IEM), (AY(K),K=1,IEM),
2(PHI(K),K=1,IEM)
5 CONTINUE
RETURN
END

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AMAT 121
AMAT 122
NOV89 56
NOV89 57
AMAT 123
AMAT 124
AMAT 125
AMAT 126
AMAT 127
AMAT 128
AMAT 129
AMAT 130
AMAT 131
AMAT 132
AMAT 133
AMAT 134
AMAT 135
AMAT 136
AMAT 137
AMAT 138
AMAT 139
AMAT 140

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[illegible]

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FTN 4.5-410

SUBROUTINE OUTPUT 73/73 OPT=1

OUTPUT 59
 OUTPUT 60
 OUTPUT 61
 MOV08 20
 OUTPUT 63
 OUTPUT 64
 OUTPUT 65
 OUTPUT 66

WRITE(6,2002)XCP(3,1),XCP(3,1),VVZ
 5 CONTINUE
 RETURN
 2001 FORMAT(1H0,7HELEMENT,3X,7HREF NO.,3X,8HMOD CODE,5X,2HAC,9X,
 23HACP,7X,12-H COMPONENTS,10X,1HV,17X,3HPHI,15X,3HSIG)
 2000 FORMAT(1H0,3I15,5X),2(2X,F8.4),5(F15.4,2X))
 2002 FORMAT(1H,30X,2(2X,F8.4),F15.4)
 END

60

65

CARD NR. SEVERITY DETAILS DIAGNOSIS OF PROBLEM

19 I XCP8 ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
 19 I XCP8 ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.

[illegible]

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FTN 4.5+410

SUBROUTINE PRESF 73/73 OPT=1

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60      Y=T*DT(I)
        DO 13 J=1,2
          DM(J)=DM(J+1)
          ACP8(J,1)=XCP8(J+1,1)
          XCP9(J,2)=XCP8(J+1,2)
          XCP9(J,3)=XCP8(J+1,3)
          ANG(J)=ANG(J+1)
          HMAX(J)=HMAX(J+1)
          DO 13 K=1,IEM
            IO(J,K)=IO(J+1,K)
            IM(J,K)=IM(J+1,K)
            PH(J,K)=PH(J+1,K)
            VVZ(J,K)=VVZ(J+1,K)
            VVY(J,K)=VVY(J+1,K)
            VVZ(J,K)=VVZ(J+1,K)
            AREA(J,K)=AREA(J+1,K)
          DO 13 L=1,3
            XCP(J,L,K)=XCP(J+1,L,K)
            XH(J,L,K)=XH(J+1,L,K)
          IC42=IEM
          READ(17) IEM,ANG(3),XCP8(3,1),XCP8(3,2),XCP8(3,3),DH(3),HMAX(3)
          DO 15 J=1,IEM
            READ(17) IO(3,J),IM(3,J),PH(3,J),VVY(3,J),VVZ(3,J),VVZ(3,J)
            * (ACP(3,K,J),K=1,3), (XH(3,K,J),K=1,3), AREA(3,J)
          15 CONTINUE
          COST=COS(198.-ANG(2))/CONVR
          SINT=SIN(198.-ANG(2))/CONVR
          IF (HIM-67.1-E-08.AMD.1.EQ.1) GO TO 40
          DO 25 J=1,IEM2
            IFAC=IO(2,J)
            IPAS=IFUT=0
            DO 30 K=1,IEM
              C.....DETERMINE OPTION FOR PHI DOT
                IF (IO(1,K)-EQ.1) IFAC=K
                IF (IO(3,K)-EQ.1) IFUT=K
              30 CONTINUE
                IF (IPAS.EQ.0) GO TO 71
                IF (IM(1,IPAS)-EQ.0) GO TO 72
                IF (IM(2,J)-EQ.0) GO TO 74
                71 DM1=PHI=0.0
                  IF (IMODE.EQ.0) GO TO 73
                  IF (IPAS.EQ.0) GO TO 73
                  74 DM1=XCP(1,3,IPAS)
                    PHI=PHI(1,IPAS)
                    GO TO 73
                  72 DM1=XCP(1,3,IPAS)
                    PHI=PHI(1,IPAS)
                  73 DM3=XCP(3,3,IFUT)
                    PH3=PHI(3,IFUT)
                    PH3=PHI(3,IFUT)
              C.....CALCULATE PHI DOT
                RZ=XCP(2,3,J)-XCP8(2,3)
                RY=XCP(2,2,J)-XCP8(2,2)
                D1=DM1*DT(I)/CONVR
                D2=DM2*(1+DT(I))/CONVR
                VZP=VEZ(I)+(RZ*(1.-COS(D1))-RY*SIN(D1))/DT(I)
                VY=VEZ(I)+(RZ*(1.-COS(D2))-RY*SIN(D2))/DT(I+1)
                CWP=(VZP*DT(I)-DM(2))/(VZP*DT(I))

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115      CMF=(VZF*OT(1,1)-DM(3,3))/(VZF*OT(1,1))
      DELT1=(XCP(2,3,3)-DM(1,1))/(CMF*VZF)
      DELT2=(DM(3,3)-XCP(2,3,3))/(CMF*VZF)
      DPH1=DPH(2,3,3)-DM(1,1)/DELT1
      DPH2=DPH(3,3)-DM(2,3,3)/DELT2
      DPH=DPH1+DPH2
      V2=VX(12,3,3)+2*VY(2,3,3)+2*VZ(12,3,3)+2
      FCP(1,1,1)=2*DPH/VENTRY2
      IF (ICOM.EQ.0) FCP(1,1,1)=FCP(1,1,1)/CMF(1,1)
      DOTX=VEX(1,1)*VEX(1,1)
      DOTY=VEY(1,1)*VEY(1,1)
      DOTZ=VEZ(1,1)*VEZ(1,1)
      FCP(2,3,3)=(DOTX*VX(2,3,3)+DOTY*VY(2,3,3)+DOTZ*VZ(2,3,3)-V2)/VENTRY2
      IF (IM(2,3,3).NE.1) GO TO 60
      FCP(1,1,1)=FCP(1,1,1)*CF
      FCP(2,3,3)=FCP(2,3,3)*CF
60      CONTINUE
      IF (IM(2,3,3).NE.0) DSSS(10(2,3,3))=0.0
      DSSS(10(2,3,3))=DSSS(10(2,3,3))-DELT1
      C.....TRANSFORM COORDINATES
      XC(2,3,3)=SINT*RY+COST*RZ+ CGL
      XC(1,1,1)=COST*RY-SINT*RZ
25      CONTINUE
      DO 50 J1=1,NCW
      FR=FY=FZ=SMX=SMY=SMZ=0.0
      IFLAG=0
      IF (ICOM.EQ.1) GO TO 83
      C.....CONSTANT ORIENTATION OUTPUT
      VDOM=VENTRY*COST*CM(J1)
      W=MAX(2)
      T=H/VDOM
      TSAR=VENTRY*T/D
      WRITE(6,2005) I1,M,T,TSAR,CM(J1)
      WRITE(6,2000)
      DO 51 KI=1,ICM2
      IF (10(2,3,3).LT.WMLD.OR.1FLAG.EQ.1) GO TO 75
      IFLAG=1
      WRITE(6,2012)
75      CONTINUE
      CP=FCP(1,1,1)*CM(J1)+FCP(2,3,3)
      IF (10(2,3,3).LT.WMLD.AND.CP.LT.0) CP=0.0
      PRES=CP*.97*VENTRY2
      IF (10(2,3,3).GE.WMLD) PRES=0.0
      TES=XCP(2,3,3)+VENTRY/(VDOM*0)
      FORCET=PRES*AREA(2,3,3)
      WRITE(6,2001) KI,10(2,3,3),IM(2,3,3),AREA(2,3,3),PRES,FORCET
      * KC(1,1,1)+XC(2,3,3)+TES*CP,PRES,FORCET
      F1=-XM(2,3,3)+FORCET
      F2=-XM(2,3,3)+FORCET*APHI
      F3=-XM(2,3,3)+FORCET*JPHI
      F4=F1*F1
      F5=F2*F2
      F6=F3*F3
      F7=F4*F4
      F8=XCP(2,3,3)+XC(2,3,3)
      RAY=XCP(2,3,3)+XC(2,3,3)
      RAZ=XCP(2,3,3)+XC(2,3,3)
      SML=SMX+RAY*F3-RAZ*F2

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MOV05 26
PRESF 107
MOV05 29
MOV05 30
MOV05 31
MOV05 24
MOV05 33
PRESF 113
MOV06 1
JAN10 10
JAN10 11
JAN10 12
JAN10 13
DEC27 27
DEC27 28
DEC27 29
DEC15 7
MOV08 26
MOV08 27
PRESF 116
PRESF 121
PRESF 122
PRESF 123
PRESF 124
DEC14 20
DEC27 30
MOV02 5
PRESF 127
PRESF 128
PRESF 129
PRESF 130
PRESF 131
PRESF 132
PRESF 133
PRESF 134
DEC27 31
DEC27 32
DEC27 33
DEC27 34
PRESF 135
DEC27 35
PRESF 137
DEC15 16
PRESF 139
PRESF
PRESF
MOV08 28
DEC14 22
MOV11 74
MOV11 75
DEC14 23
PRESF 144
PRESF 145
DEC14 24
DEC14 25
DEC14 26
DEC14 27

```

```

175 SMY=SMY-RAX*F3+RAZ*F1
    SMZ=SMZ-RAX*F2-F1*RAY
    51 CONTINUE
    60 TO 81
    83 CONTINUE
    C.....VARIABLE ORIENTATION OUTPUT
    WRITE(6,2006)I,MMAX(2),T,TSSS,CNT(1),CNT(1+1)
    WRITE(6,2007)(VEY(1+1),VEY(1+1)/2,+(VEY(1+1)-VEY(1+1))/2,
    1VEZ(1+1),VEZ(1+1)/2,+(VEY(1+1)-VEY(1+1))/2,ANG(2)
    WRITE(6,2008)
    DO 52 KI=1,ITEMZ
    IF (IO(2,KI).LT.NMULD.OR.IFLAG.EQ.1)60 TO 76
    IFLAG=1
    76 CONTINUE
    WRITE(6,2012)
    CP=FCP(1,KI)+FCP(2,KI)
    IF (IO(2,KI).LT.NMULD.AND.CP.LT.0)CP=0.0
    PRES=CP*.97*VENTRYZ
    IF (IO(2,KI).GE.NMULD)PRES=0.0
    FORCET=PRES*AREA(2,KI)
    YES=OSSS(IO(2,KI))*VENTRYZ/D
    WRITE(6,2001)KI,IO(2,KI),IM(2,KI),AREA(2,KI),XCP(2,1,KI),XC(1,KI)
    1XC(2,KI),YES,CP,PRES,FORCET
    F1=-XM(2,1,KI)*FORCET
    F2=-XM(2,2,KI)*FORCET*XPNI
    F3=-XM(2,3,KI)*FORCET*XPNI
    F4=F1+F1
    F5=F2+F2
    F6=F3+F3
    RAX=XCP(2,1,KI)-NCP8(2,1)
    RAY=XCP(2,2,KI)-NCP8(2,2)
    RAZ=XCP(2,3,KI)-NCP8(2,3)
    SMY=SMY-RAX*F3-RAZ*F1
    SMZ=SMZ-RAX*F2-F1*RAY
    82 CONTINUE
    81 CONTINUE
    IF (IPNI.EQ.1)FX=SMY-SMZ*0.0
    FN= FZ*SINT-FY*COSI
    FD=(FZ*COSI-SINT*FY)
    WRITE(6,2002)FX,FD,FX,SMY,SMZ
    CX=FX/SCALE
    CY=FY/SCALE
    CD=FD/SCALE
    CMX=SMY/SCALED
    CMY=SMZ/SCALED
    CMZ=SMZ/SCALED
    WRITE(6,2011)CX,CD,CM,CMY,CMZ
    50 CONTINUE
    40 CONTINUE
    RETURN
    2000 FORMAT(1H6,1X,3HMO,2X,7HREF.MO,2X,3HNO,5X,4HAREA,8X,1HX,9X,1HY,
    +9X,1HZ,12X,2HY,7X,2HCP,18X,1HP,9X,5HFORCET)
    2001 FORMAT(1H,31(16,2X),E12.4,3(1X),2X,F7.4,3X,F7.2,3X,
    +2(12,4,1X))
    2002 FORMAT(1H6,5HFX = ,E15.7,2X,5HFD = ,E15.7,2X,5HFN = ,E15.7,
    +2X,6HSMY = ,E15.7,2X,6HSMZ = ,E15.7,2X,6HSMZ = ,E15.7)

```


SUBROUTINE PRESF 73/73 OPT=1

CARD NO. SEVERITY DETAILS DIAGNOSIS OF PROBLE-4

[illegible]

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SUBROUTINE SUAS 73/73 OPT=1

```

1  SUBROUTINE SUAS(IEM,IAVS,NBLK,A,IP,VNO,SIG,STOR)
C.....THIS SUBROUTINE SETS UP BLOCKS AND CALLS DECOMP AND SOLVE
C.....DIMENSION ALL(SIG(I),IP(I),VNO(I),STOR(I))
C.....TRANSFER NORMAL VELOCITY
DO 5 K=1,IEM
  IP(K)=K
  5 SIG(K)=VNO(K)
  IF(IEM.GT.NBLK)GO TO 15
C.....BLOCKS ARE NOT NECESSARY
DO 66 J=1,IEM
  READ(16) (A((I-1)*IEM+J),J=1,IEM)
  66 CONTINUE
  REWIND 16
  IEM2=IEM/IEM
  CALL WRITMS(3,A,IEM2,1)
  NR=IEM
GO TO 50
C.....BLOCKS ARE NEEDED
15 NMAX=IAVS/IEM
  NUN=IEM/NMAX
  IF (NUN.NE.1)NUN=NUN-1
C.....CONSTRUCT BLOCKS
  NR=NMAX
DO 10 I=1,NUN
  NB=1+(I-1)*NMAX
  NU=I*NMAX
  IF(I.EQ.NUN)NU=IEM
DO 20 K=1,IEM
  READ(16) (STOR(I),I=1,IEM)
  IC=1
DO 20 J=NB,NU
  IC=IC+1
  TBL=IC/IEM*N
  A(IK)=STOR(IJ)
  20 CONTINUE
  NUT=(NU-NB+1)*IEM
  CALL WRITMS(3,A,NUT,1)
  10 CONTINUE
  50 CONTINUE
C.....SOLVE
  CALL DECOMP(IEM,NR,A,IP)
  IF(IP(IEM).NE.0)GO TO 51
  WRITE(6,2000)
  2000 FORMAT(1H,30X,'SINGULAR MATRIX')
  STOP
  51 CONTINUE
  CALL DSOLVE(IEM,NR,A,SIG,IP)
  RETURN
END

```

```

1  SUBROUTINE DDECOMP(M,MP,R,IP)
   DIMENSION R(1),IP(1)
   INTEGER RSUBKN,RSTUB
   DATA EPS/1.0E-10/
   M1=M-1
   MEL=M*MP
   IP(M)=N
   MBLOCK=N/MP
   MP=MBLOCK*MP
   IF (MP.LT.N) MBLOCK=MBLOCK+1
   NMEL=MEL+MEL
   IDA1=1
   PSUBKN=N
   CALL READMS(3,R,MEL,IDA1)
   DO 6 K=1,MM1
     RSUBKN=PSUBKN+N
     IF (PSUBKN.ME.MEL) GO TO 30
     IF (IDA1.GT.MBLOCK) GO TO 30
     CALL WRITMS(3,R,MEL,IDA1-1)
     CALL READMS(3,R,MEL,IDA1)
     IDA1=IDA1+1
     PSUBKN=0
30  CONTINUE
   KPI=K+1 $ KLOW=RSUBKN-KPI $ KHIGH=RSUBKN+N
   MERR=K*PSUBKN
   RM=R(M)
   DO 1 I=KLOW,KHIGH
     IF (ABS(R(I)).LE.ABS(RM)) GO TO 1
     RM=R(I)
     M=I
1  CONTINUE
   T=-R(M)
   IF (ABS(T).LE.EPS) GO TO 7
   MK=M-RSUBKN
   KSAVE=IP(K)
   IP(K)=IP(MK)
   IP(MK)=KSAVE
   R(M)=R(MK)
   R(MK)=T
12  IDA2=IDA1
   IF (IDA1.GT.MBLOCK) GO TO 40
   CALL READMS(3,R(MEL+1),MEL,IDA2)
   IDA2=IDA2+1
40  CONTINUE
   RSTUB=RSUBKN
   IFLAG=0
   DO 2 I=KPI,N
     RSTUB=RSTUB+N
     IF (RSTUB.LT.NMEL) GO TO 50
     CALL WRITMS(3,R(MEL+1),MEL,IDA2-1)
     CALL READMS(3,R(MEL+1),MEL,IDA2)
     IDA2=IDA2+1
     RSTUB=MEL
50  CONTINUE
   TI=R(RSTUB+MK)
   IF (MK.EQ.K) GO TO 11

```

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SUBROUTINE DDECOMP 73/73 OPT=1

```

60      IF (IFLAG.EQ.1) GO TO 68
        IFLAG=1
        ISTUB=1
        61      IF (ISTUB.EQ.IDX1-1) GO TO 69
            CALL READMS(3,R(NEL*1),NEL,ISTUB)
            KSTUB=NEL
            DO 62 KK=1,NR
                T2=R(KSTUB+KK)
                R(KSTUB+KK)=R(KSTUB+K)
                R(KSTUB+K)=T2
            KSTUB=KSTUB+N
        62      CONTINUE
            CALL WRITMS(3,R(NEL*1),NEL,ISTUB)
            ISTUB=ISTUB+1
            GO TO 61
        63      IF (IDX1.GT.NBLOCK) GO TO 63
            CALL READMS(3,R(NEL*1),NEL,IDX2-1)
        63      CONTINUE
        64      CONTINUE
            IF (KSUBKN.EQ.RSUBKN) GO TO 68
            T2=R(KSUBKN+KK)
            R(KSUBKN+KK)=R(KSUBKN+K)
            R(KSUBKN+K)=T2
            KSUBKN=KSUBKN+N
            GO TO 64
        65      CONTINUE
            R(RSTUB+KK)=R(RSTUB+K)
            11      R(RSTUB+K)=T1/T
            DO 2 J=KPI,N
                2      R(RSTUB+J)=R(RSTUB+J)+R(RSUBKN+J)
                    IF (NBLOCK.EQ.1) GO TO 6
            CALL WRITMS(3,R(NEL*1),NEL,NBLOCK)
        6      CONTINUE
            CALL WRITMS(3,R,NEL,IDX1-1)
            IF (IP(RSUBKN+N*N).GT.EPS) RETURN
        7      IF (N)=0
            RETURN
        END
95

```

SUBROUTINE	OSOLVE	73/73	OPT=1	FTN 4.5-410	77/01/17, 11-07-10	PAGE	1
1	SUBROUTINE OSOLVE(N,NR,R,B,IP)				DEC01	160	
	DIMENSION R(1),B(1),IP(1)				DEC01	161	
	INTEGER RSUBKN				DEC01	162	
5	NM1=N-1				DEC01	163	
	NFL=N*NR				DEC01	164	
	NBLOCK=N/NR				DEC01	165	
	NP=NBLOCK*NR				DEC01	166	
	IF (NP.LT.N) NBLOCK=NBLOCK+1				DEC01	167	
	IDX=1				DEC01	168	
10	RSUBKN=0				DEC01	169	
	CALL READMS(3,R,MEL,IDX)				DEC01	170	
	IDX=IDX+1				DEC01	171	
	DO 200 I=2,N				DEC01	172	
15	RSUBKN=RSUBKN+N				DEC01	173	
	IF (RSUBKN.NE.MEL) GO TO 30				DEC01	174	
	RSUBKN=0				DEC01	175	
	CALL READMS(3,R,MEL,IDX)				DEC01	176	
	IDX=IDX+1				DEC01	177	
20	30 CONTINUE				DEC01	178	
	YI=B(I)				DEC01	179	
	YI=I-1				DEC01	180	
	DO 220 J=1,IM1				DEC01	181	
	YI=YI+R(RSUBKN+J)*B(J)				DEC01	182	
25	220 CONTINUE				DEC01	183	
	B(I)=YI				DEC01	184	
	200 CONTINUE				DEC01	185	
	IDX=NBLOCK				DEC01	186	
30	B(N)=B(IM1)/R(RSUBKN+N)				DEC01	187	
	DO 230 II=1,NM1				DEC01	188	
	I=N-II				DEC01	189	
	RSUBKN=RSUBKN-N				DEC01	190	
	IF (RSUBKN.LT.0) 221,225				DEC01	191	
35	221 IDX=IDX-1				DEC01	192	
	CALL READMS(3,R,MEL,IDX)				DEC01	193	
	RSUBKN=MEL-N				DEC01	194	
	225 CONTINUE				DEC01	195	
	XI=B(I)				DEC01	196	
	IPI=I+1				DEC01	197	
40	DO 260 J=IPI,N				DEC01	198	
	XI=XI-R(RSUBKN+J)*B(J)				DEC01	199	
	260 CONTINUE				DEC01	200	
	B(I)=XI/R(RSUBKN+1)				DEC01	201	
45	230 CONTINUE				DEC01	202	
	DO 300 K=1,N				DEC01	203	
	M=IP(K)				DEC01	204	
	R(N)=B(K)				DEC01	205	
	300 CONTINUE				DEC01	206	
	DO 301 K=1,N				DEC01	207	
50	301 B(K)=R(K)				DEC01	208	
	RETURN				DEC01	209	
	END				MATRIX	88	

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SUBROUTINE CENT 73/73 OPT=1

```

1  SUBROUTINE CENT(X,XC,IS,IEM,AREA)
   DIMENSION X(3,1),XC(3,1),IS(4,1),AREA(2,1),XTT(3,2),THETA(2)
   DO 10 K=1,IEM
     I1=IS(1,K)
     I2=IS(2,K)
     I3=IS(3,K)
     I4=IS(4,K)
     C.....CALCULATE AREAS
     A1=A2=B1=B2=C=0.6
     DO 44 I=1,3
       A1=A1+(X(I,I2)-X(I,I1))**2
       B1=B1+(X(I,I3)-X(I,I2))**2
       C=C+(X(I,I3)-X(I,I1))**2
       A2=A2+(X(I,I4)-X(I,I1))**2
       R2=B2+(X(I,I3)-X(I,I4))**2
     44 R2=B2+(X(I,I3)-X(I,I4))**2
     DHD=(A1*B1-C)/2./SQRT(A1*B1)
     EME=(A2*B2-C)/2./SQRT(A2*B2)
     IF (DHD.GT.1.)DHD=1.
     IF (DHD.LT.-1.)DHD=-1.
     IF (EME.GT.1.)EME=1.
     IF (EME.LT.-1.)EME=-1.
     THETA(1)=ACOS(DHD)
     THETA(2)=ACOS(EME)
     AREA1=.5*SORT(A1*B1)*SIN(THETA(1))
     AREA2=.5*SORT(A2*B2)*SIN(THETA(2))
     AREA(2,K)=AREA1+AREA2
     C.....CALCULATE CENTROIDE IN BODY COORDINATES
     DO 60 L=1,3
       XTT(L,1)=(X(L,I1)+X(L,I2)+X(L,I3))/3.
       XTT(L,2)=(X(L,I1)+X(L,I3)+X(L,I4))/3.
     60 CONTINUE
     DO 70 L=1,3
       XC(L,K)=(AREA1*XTT(L,1)+AREA2*XTT(L,2))/AREAT
     70 XC(L,K)=(AREA1*XTT(L,1)+AREA2*XTT(L,2))/AREAT
     10 CONTINUE
     RETURN
   END

```

2 CENT
 7 WOV02
 4 CENT
 5 CENT
 6 CENT
 7 CENT
 8 CENT
 9 CENT
 10 CENT
 11 CENT
 12 CENT
 13 CENT
 14 CENT
 15 CENT
 16 CENT
 17 CENT
 18 CENT
 19 CENT
 20 CENT
 21 CENT
 22 CENT
 23 CENT
 24 CENT
 25 CENT
 26 CENT
 27 CENT
 28 CENT
 29 CENT
 30 CENT
 31 CENT
 32 CENT
 33 CENT
 34 CENT
 35 CENT
 36 CENT
 37 CENT

APPENDIX C

USER INSTRUCTIONS AND SAMPLE RUNS

The current version of the code can be applied to arbitrary bodies. It was developed on a CDC 6500 and requires about 105K storage octal. The grid describing the entry body may contain up to 750 nodes* and 500 elements, however, execution will terminate when more than 300 of these elements become submerged. This appendix describes the available program options, necessary input cards and output format. Sample runs are provided to illustrate the use of this program.

Program Options and Required Input

Program input can be divided into three parts. In the first, the basic program options are specified:

Card No.	Variable	Format
1	CONSTANT or VARIABLE body orientation	2A4
2	PRINT or DON'T PRINT	3A4
3	ASYMMETRIC or SYMMETRIC mode	3A4

Under the CONSTANT body orientation option the entry model is assumed to retain its initial orientation and velocity throughout the entry process. As discussed previously, the natural problem variable in this case is depth rather than time. With little increase in computational time, pressures and forces can be evaluated for a number of different wetting factors, C_w . The VARIABLE body orientation option allows the velocity, orientation, wetting factor and time increments between steps to be varied. The only restriction is that the angular velocity of the body must be small enough to insure that the depth of the body increases monotonically in time. The maximum number of steps is limited to 49.

The PRINT option is used to obtain flow field and element information at each step of the calculation. It is applied only for diagnostic purposes. The second option, DON'T PRINT, is recommended and produces only grid information and the final pressures and forces on the model.

If the SYMMETRIC mode option is used, the entry model is assumed to possess planar symmetry about the y-z plane. The ASYMMETRIC option does not assume any symmetry and hence can be applied to arbitrary bodies. This mode is also used on symmetric bodies where V_x is none-zero.

*Storage is set up for 800 nodes. However, this must also include room for nodes generated at each step.

The second set of input cards describes the entry conditions and the required information differs depending on whether the CONSTANT or VARIABLE body orientation option is used. For the CONSTANT option the following data cards are required:

Card No.	Variables	Format
4	IMAX, D, VENTRY, ANG, SUMT, HMIN, DH, ALPHA	15, 5X, 7F10.0
5	CGL, FCF, ANGB, NNLD	3F10.0, I5
6	NCW, CW(1), CW(2).....(CW(NCW))	15, 5X, 7F10.0/ (8F10.0)
7	omit	

These variables are defined as follows:

IMAX	Number of steps at which pressures and loads are calculated. The present calculative procedure inserts the model into the water in a series of steps, each at a greater depth than the preceding one. When the step count becomes greater than IMAX execution is terminated
D	Diameter (in feet). This quantity is only used for calculating force coefficients
VENTRY	Entry velocity in ft/sec
ANG	Orientation of the model (in degrees) relative to the water surface (see Fig. C-1)
SUMT	Program time limit. This must correspond to the time limit on the job card
HMIN	Initial body depth (i.e., measured from the lowest point on the body). This parameter is zero if the loads are calculated from time of initial wetting. Note that if this variable is not zero pressures and forces are first calculated at $HMIN + 2DH$. This parameter allows pressures and forces at a particular depth to be determined without calculating the entire force-time history from initial wetting.
DH	Increment in depth in feet between successive steps. It is necessary to coordinate this variable with the specified model grid which is defined on the last set of data cards. The following apply to determining DH: a. OBLIQUE ENTRY WITH STANDARD GRID OPTION. DH should be picked so that the average element is submerged in two steps. On models of complex shape this criteria can only be satisfied in the mean and primary consideration should be given to the portion of the body which experiences the greatest load. Generally this will be on elements whose plane is perpendicular to the direction of motion.

b. VERTICAL ENTRY WITH STANDARD GRID OPTION OR OBLIQUE ENTRY WITH THE OGIVE OPTION. For vertical entry or if the OGIVE grid option is used, elements will have a pair of side parallel to the water surface. In this case it is important to choose the step size very precisely so that each element will be submerged in exactly two steps. To insure that the top row of elements is included in an unmodified state in the code and that the next row of elements is excluded, the actual water surface should fall a small distance ϵ above the upper edge of the top row of element to be included as shown in Figure C-2. Here $0 < \epsilon < \Delta h$ where Δh is defined by

$$\Delta h = \frac{\sqrt{\text{average element area}}}{1000}$$

ALPHA Angle of attack in degrees (see Fig. C-1)

CGL z' coordinate of the center of gravity (see Fig. C-1)

FCF Pressure correction factor on elements with a modification code of 1. For the oblique entry of blunt bodies (nose length/diameter < 1) set to unit. For other cases use a value of .67.

ANGB Yaw angle in degrees of \bar{V}_T . Velocity components in the x,y,z direction are $V_T \sin(\text{ANGB})$, $-V_T \cos(\text{ANG}) \cos(\text{ANG} + \text{ALPHA})$ and $-V_T \cos(\text{ANG}) \sin(\text{ANG} + \text{ALPHA})$

NNLD Number of wetting factors to be used. Since the most appropriate value may not be clear, for little extra computational cost pressure and loads may be calculated for several different wetting factor values

CW Wetting Factor. This parameter describes the rate of surface rise and is equal to the ratio of h/h' defined in Figure 1. For best results, the test cases reported on should be used as a guide. An approximate rule for determining this parameter is as follows:

- (1) POINTED BODIES (ALSO INCLUDES SLIGHTLY BLUNTED ONES). Determine the angle, θ_c , between the tangent to the body surface and the body axis at both the nosetip and base of the nose. At the nose neglect any effect due to body blunting. Insert the two resulting values of θ_c in radians into:

$$C_w = \frac{1}{[1 - .396\theta_c + .287\theta_c^2 - .124\theta_c^3]} \quad (\text{C-1})$$

Average the two calculated values of C_w to obtain the final one to be used in the code. If ALPHA is non-zero increment θ_c by ALPHA

- (2) FLAT PLATES. Use a value of 1.45 for $ANG > 45$ degrees and 1.55 for $ANG < 45$.
- (3) SPHERICAL BODIES. Use a value of 1.55 for near vertical entry and 1.35 for oblique entry.

The classification of an arbitrary body into one of the above categories is a matter of experience. On complex shapes classification should be based on the portion of the body sustaining the majority of the impact loading.

If the VARIABLE body orientation option is used the following data cards are required:

Card No.	Variables	Format
4	IMAX, D, VENTRY, ANG, SUMT, HMIN	15, 5X, 7F10.0
5	CGL, FCF, NNLD	2F10.0, 10X, 15
6	NVP	
7.1	VX(1), VY(1), VZ(1), CW(1), DH(1)	6F10.0
.		
7.NVP	VX(NVP), VY(NVP), VZ(NVP), WX(NVP), CW(NVP), DH(NVP)	6F10.0

The variables on cards 4 and 5 are defined above. In this case, VENTRY is only used in determining the force and pressure coefficients and ANG is the initial body orientation. The body velocity, wetting factor, and increment in depth for each step is defined in cards 7.

NVP Number of different steps at which entry conditions are specified

VX(I), VY(I), VZ(I) Velocity components in the x,y,z directions of the center of gravity in ft/sec applied between steps I-1, and I

WX(I) Angular velocity in degrees/sec in the pitch (y-z) plane applied between steps I-1 and I

CW(I) Wetting factor applied between the I-1 and I step. If the value of this parameter remains constant from step to step use the instruction for determining this variable given in the CONSTANT orientation section. For the vertical entry ($VX=VY=0$) of pointed bodies an estimate of this parameter for each step can be obtained by:

a. Determining the depth of the entry body, H, below the original surface at the start of the step

b. Calculating the angle, θ'_c between a tangent to the body surface and the body axis, $z'_f = H$

c. Substituting into equation (C-1) to determine C_w . Where

$$\theta_c = \theta_c' + 90 - \text{ANG}$$

d. For blunt bodies, [(nose length)/diameter] < .75, increase this angle by 7% on ogives and decrease it by the same amount on cusps

DH(I) Increase in depth in feet of the center of gravity between steps I-1 and I. See instruction in the CONSTANT orientation entry section

The entry velocity at step I is taken to be the average of that at steps I-1 and I. It is only necessary to specify data cards for the first few steps in which the above parameters change. For steps larger than NVP the parameter values at step NVP are used.

The final set of data cards is used to define the grid on the surface of the entry body. The three available options for constructing a grid on the body surface are STANDARD, OGIVE and LIST. These can be used singularly, in combination with one another and can be called in arbitrary sequence. The only restriction is that the lowest point on the body should occur on that part of the grid constructed by the first option called. To indicate the desired options, the following input cards are required:

Card No.	Variable	Format
8	N	15
9.1	option 1	3A4
.		
9.N	option N	3A4

Here N is the number of options to be used. Recommended options are provided in Table C-1.

The grid representing the surface of the entry body should cover only the nose of the model and not the afterbody. In all cases the pressures on the afterbody are small. Furthermore, on bodies with sharp shoulders such as a disk cylinder, the flow separates at the edge of the model face. If the afterbody is gridded, the flow is required not to separate since the inviscid boundary conditions are enforced at the centroid of each element. This is physically unrealistic and hence neglecting the afterbody is appropriate.

A description of the three available options follows. Under no circumstances should right angles be modeled directly. If the body under consideration has such a surface discontinuity, it should be modeled with a 89.9 or 90.1 degree angle.

STANDARD

This option is applicable to axisymmetric bodies or axisymmetric portions of arbitrary bodies. The user specifies rings along which nodes are located. Adjacent nodes are combined to form elements. A typical grid for a flat, circular plate is shown in the Figure C-3. The required input is:

Card No.	Variables	Format
10	NROWS, IANG, ISUP	315
11.1	R(1), Z(1)	2F10.0,15
.		
.		
11.NROWS	R(NROWS), Z(NROWS), IW(NROWS)	2F10.0,15

IANG If IANG = 0, only half of the face is gridded as shown.
 If IANG = 1, the complete face is gridded

NROW **Number of grid rings**

ISUP If ISUP = 1, the stagnation element (number 1) is removed. This option is used for running pointed objects. For such bodies, R(1) should be very small (i.e., D/1000) but must be finite.

If ISUP = 0 this element is included.

R(I) Radius of ring I in body fixed coordinates (x' , y' , z') in feet.

Z(I) z' coordinate of ring is in feet.

IW(I) number of elements in the area between rings I and I-1.
Delete this variable on card 1. If IW = 0, elements are
automatically selected so that they are approximately square.

LIST

This option requires that the user input the list of nodes and elements to be used in the run and hence is applicable to arbitrary bodies. The nodes can be read in any order, however, they are numbered sequentially for internal use in the code. Each element is constructed using nodes from the input list. The identification numbers of nodes defining the four corners of each element must be read in a clockwise order with respect to an observer on the outer surface of the element. The required input cards are:

Card No.	Variable	Format
10	NP, NE	215
11.1	$x'(1), y'(1), z'(1)$	3F10.0
.		
11.NP	$x'(NP), y'(NP), z'(NP)$	3F10.0
12.1	IN(1,1), IN(2,1), IN(3,1), IN(4,1)	415
12.NE	IN(1,NE), IN(2,NE), IN(3,NE), IN(4,NE)	415
NP	number of node points to be read in.	
NE	number of elements to be read.	
$x'(I), y'(I)$ $z'(I)$	location of the Ith node in body fixed coordinates (x', y', z') in feet	
IN(1,I), IN(2,I), IN(3,I), IN(4,I)	Identification number of the nodes defining the four corners of the element	

OGIVE

This subroutine is applicable to pointed axisymmetric bodies entering obliquely. It grids the body surface with elements having a pair of edges parallel to the water surface as shown in Figure C-4. This feature is particularly desirable for conical bodies where ANG is less than 90 degrees. Under these conditions the described code produces conical results and the complete pressure-time history can be obtained using calculated values at a single depth. This subroutine allows elements to be packed near the water surface and minimizes the need to use the local similarity assumption. Use of this subroutine is also recommended for examples in which normal force is of importance. Alignment of elements with the water surface will produce more accurate results than the STANDARD grid option. If this subroutine is used to grid non-conical bodies, the constructed element will be slightly non-planar, however, this does not seriously effect the calculations.

Card No.	Variable	Format
10	NROWS, NBODY, IANG	315
11.1	R(1), Z(1)	2F10.0
.		
11.NBODY	R(NBODY), Z(NBODY)	2F10.0
12.1	H(1), B(1), IW(1)	2F10.0,15
12.NROWS	H(NROWS), B(NROWS), IW(NROWS)	2F10.0,15

Here cards 11 are used to specify the body shape while cards 12 define the grid. Up to 50 points may be used to define the body. Between these points the body is defined by linear interpolation.

The above variables are defined as:

NROWS	Number of element rows
NBODY	Number of points defining the body geometry
IANG	If IANG = 0 only the right half of the body is gridded. If IANG = 1 the entire body is gridded
R(I), Z(I)	Polar coordinates of body profile in feet. $R = (x'^2 + y'^2)^{1/2}$, $Z = z'$. R(1) and Z(1) must be zero
H(I)	z' coordinate of the upper edge of the Ith element row in the $y'-z'$ plane in feet
B(I)	Orientation in degrees of the entry body axis with respect to the water surface at the end of step 21. If the entry is under constant condition B(I) is equal to ANG
IW(I)	Number of elements in the Ith row. Must be specified.

SAMPLE RUNS

Four sample runs have been provided to illustrate the use of various code options. In each case a brief discussion is given of the entry problem and its particular peculiarities. This is followed by a listing of the input cards and the resulting output. In the final section of this appendix a discussion is given of the output format. Table C-2 gives a brief outline of the four cases to be present.

Example 1

A disk cylinder entering at 60 degrees and 100 ft/sec is modeled using a coarse, 12-element STANDARD grid. Consistent with the preceding discussion, the grid, shown in Sketch 3, covers only the face of the model. Noting that the distance between successive grid ring is .05 ft, an increment in depth of .0125 feet is chosen insuring that the average element is submerged in two steps. Consistent with instructions, C_w and FCF are set to 1.45 and 1 respectively.

Example 2

The vertical entry of a 45-degree half-angle cone at 20 degrees incidence is studied using an OGIVE grid with 10 rows of elements and 8 elements in each row. This problem is conically similar indicating that pressures and loads are adequately defined by considering only a single depth, hence $IMAX = 1$. $HMIN$ is selected as .47814 ft which places the water level just above the 8th element row and DH is set at .02988 ft to insure that each element is submerged in two steps exactly. Pressures are calculated at $HMIN + 2DH$ which corresponds to a level just above the 9th element row. Two values of C_s are used. These are arrived at by substituting $\theta \pm \text{ALPHA}$ in equation (C-1). The larger value is most appropriate on the windward ray of the cone while the smaller applies to the leeward ray.

Example 3

The vertical entry of an ogive traveling at 50 ft/sec is considered under the variable entry option. A STANDARD grid consisting of 90 elements is constructed on the body nose. The entry velocity and orientation are fixed throughout but the wetting factor is allowed to vary from step to step. The value of this parameter is determined using the procedure outlined for calculating CW under the VARIABLE entry option. The increments in depth between successive steps, $DH(I)$, are selected with care to insure that the water surface is a small distance, ϵ , above the upper edge of elements adjacent to the water surface at even numbered steps. In examining the total calculated drag a higher degree of reliability is placed on result obtained at even numbered steps.

Example 4

Entry of a disk cylinder at 60 degrees and 100 ft/sec is considered in this example. This case is included to demonstrate the use of no load elements in modeling the water-cavity interface. Each depth must be considered separately since the cavity shape changes in time. Accordingly, IMAX is set to 1. The STANDARD grid option is used to define elements on the face of the disk cylinder while LIST is applied to define a ring of no load elements extending from the edge of the disk cylinder surface to the effective planar surface. The depth of interest is taken to be .15 and hence HMIN and DH are defined as .125 and .0125 respectively. Several runs are made and the positions of the no load elements are adjusted until the calculated CP value on each of the no load elements is near zero. The illustrated output is the final run only.

PROGRAM OUTPUT

Under the initial heading of I,X,Y,Z,XC,YC,ZC are listed all nodes. Column I is the node identification number, columns X,Y,Z, are the node positions in the x',y',z' coordinates and XP,YP,ZP are the node positions in x,y,z coordinates when $h = 0$. The second section of the output lists the constructed elements. The integers under the heading ELEMENT are the element reference numbers, XC,YC,ZC are the coordinates of the element centroid referenced to the axes x',y',z' and RC and TC are the radial location measured from the z' axis and the angular position measured from the $+y'$ axis of the element centroid. The third section of output indicates numbers of the completed steps and the time required to execute that particular step. If a problem occurs during execution and the program does not terminate normally, the step in which the problem occurred can thus be determined.

The remainder of the output defines the loading on body at each step in the entry of the model. At each step the program calculates the time and dimensionless time ($V_I t/D$) from initial impact. This is followed by a listing of the submerged elements. The reference number (i.e., ref. no.) of an element is the original identification number assigned to it while its number (no.) is a temporary identification parameter for the particular depth in question. The integer under the heading of MOD identifies whether the element is modified or split. The codes 0,1 and 2 refers to unmodified, modified, and split elements respectively. The area of each element is that of its submerged portion. Also listed for each element are its pressure coefficient (CP), centroid depth in dimensionless time (T^*), pressure (P), and total load (force). The output for each depth is concluded by providing:

FX	force along the x axis
CX	X force coefficient $(FX/((\frac{\pi D^2}{4})^{1/2} \rho V_I^2))$
FD	drag force
CD	drag force coefficient $\sim FD/((\frac{\pi D^2}{4})^{1/2} \rho V_I^2)$
FN	normal force (i.e., in the $-y'$ direction)
FD	normal force coefficient $(FN/((\frac{\pi D^2}{4})^{1/2} \rho V_I^2))$
SMX	x component of moment taken about the model center of gravity
MX	x moment coefficient $SMX/((\frac{\pi D^3}{4})^{1/2} \rho V_I^2)$
SMY	y component of the moment about model center of gravity
MY	y moment coefficient $SMY/((\frac{\pi D^3}{4})^{1/2} \rho V_I^2)$
SMZ	z component of moment taken about the model center of gravity
MZ	z moment coefficient $SMZ/((\frac{\pi D^3}{4})^{1/2} \rho V_I^2)$

TABLE C-1

RECOMMENDED GRID OPTIONS

TYPE OF BODY	RECOMMENDED OPTION		COMMENTS
	Vertical Entry	Oblique Entry	
Axisymmetric Pointed	STANDARD OGIVE	OGIVE	
Axisymmetric Blunt	STANDARD	STANDARD	
All other bodies	LIST	LIST	On pointed bodies, it is advisable to construct elements with edges parallel to water surface as done in OGIVE

TABLE C-2

SAMPLE RUNS

Example	Body	Conditions	Type of Entry	Grid Options	No Load Elements
1	disk cylinder	ANG = 60 VENTRY = 100 ALPHA = 0	CONSTANT orientation	STANDARD	none
2	45-degree half-angle cone	ANG = 70 VENTRY = 100 ALPHA = 20	CONSTANT orientation	OGIVE	none
3	ogive	ANG = 90 VENTRY = 50 ALPHA = 0	VARIABLE orientation	STANDARD	none
4	disk cylinder	ANG = 60 VENTRY = 100 ALPHA = 0	CONSTANT orientation	STANDARD LIST	yes

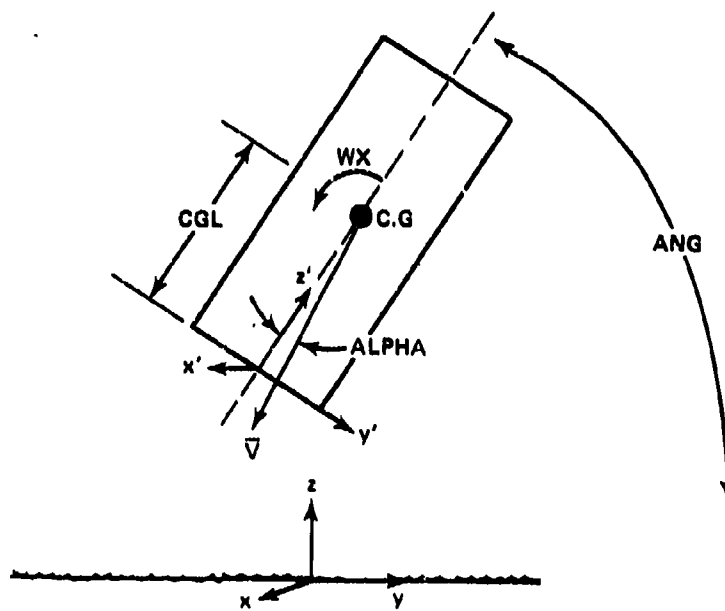


FIG. C-1

TERMS DEFINED

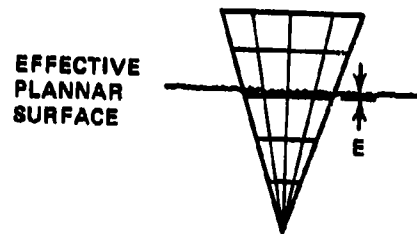


FIG. C-2 PROFILE OF CONE GRID

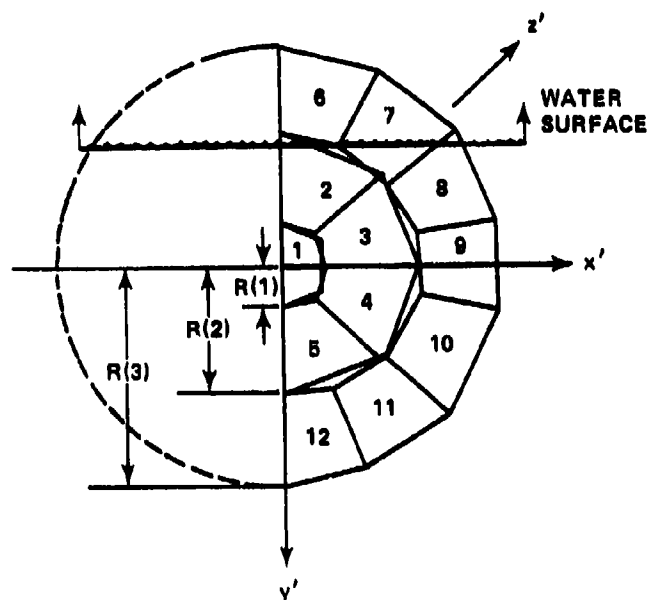


FIG. C-3 GRID OF A CIRCULAR PLATE

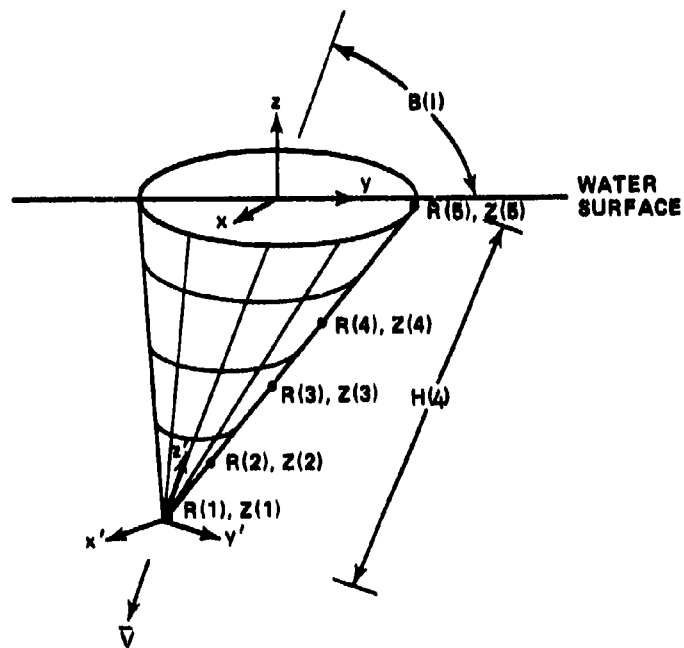


FIG. C-4

ELEMENTS HAVING A PAIR OF EDGES
PARALLEL TO THE WATER

DATA CARDS FOR EXAMPLE 1

CONSTANT					
DOWNY PRINT					
SYM.	TRIC				
11	.250	100.	60.	0.	.0125
0.	1.	0.			
1	1.45				
STANDARD					
3	0	0			
.025	0.				1
.075	0.				4
.125	0.				7

DATA CARDS FOR EXAMPLE 2

CONSTANT					
DOWNY PRINT					
SYM.	TRIC				
1	1.2	100.	70.	0	20.
0.	.67	0.			
2	1.359305	1.113171			.029885
STANDARD					
1	761VE				
10	3	0			
0.	0.				
.25	.25				
1.	1.				
.1	70.				0
.2	70.				0
.3	70.				0
.4	70.				0
.5	70.				0
.6	70.				0
.7	70.				0
.8	70.				0
.9	70.				0
1.0	70.				0

DATA CARDS FOR EXAMPLE 4

CONSTANT
 DOWNT PRINT
 SYMMETRIC
 1 1 1.250 100. 60. 30. 0.
 0. 1 1.45
 2
 STANDARD
 LIST
 3 0 1
 .025 0. 1
 .075 0. 4
 .125 0. 7
 9
 0. -5.0 3.23
 1.22 -3.55 3.23
 1.85 -2.10 3.23
 1.75 -.4180 3.23
 .99 .45 3.23
 .88 .67 3.23
 .64 .80 3.23
 0. .90 3.23
 31 32 24 23
 32 33 25 24
 33 34 26 25
 34 35 27 26
 35 36 28 27
 36 37 29 26
 37 38 30 29

EXAMPLE 1
 =====PROGRAM OPTIONS=====
 CONSTANT BODY ORIENTATION
 DON'T PRINT
 SYMMETRIC CONFIGURATION

=====PROBLEM PARAMETERS=====
 DIAMETER .2500 FT
 ENTRY VELOCITY 100.000(FT/SEC)
 BODY ORIENTATION ANGLE 40.00 DEGREES
 INITIAL DEPTH 0.0000 FT TERMINATION STEP 11
 INITIAL PRESSURE CORRECTION FACTOR = 1.0000
 CENTROID COORDINATES 0.00000 0.00000 0.00000
 INCREMENT IN DEPTH .912500
 ANGLE OF ATTACK 0.00
 YAW ANGLE 0.00

SETTING FACTORS
 1.5000

=====GRID OPTIONS=====
 STANDARD

MODE	GRID SIZE				NUMBER			
	X	Y	Z	P	X	Y	Z	P
1	0.0000	-0.0250	0.0000	0.0000	1	0.0000	0.0000	0.0000
2	-0.0217	-0.0125	0.0000	0.0000	2	-0.0217	-0.0125	0.0000
3	-0.0217	-0.0125	0.0000	0.0000	3	-0.0217	-0.0125	0.0000
4	-0.0000	-0.0250	0.0000	0.0000	4	-0.0000	-0.0250	0.0000
5	0.0000	-0.0250	0.0000	0.0000	5	0.0000	-0.0250	0.0000
6	-0.0177	-0.0177	0.0000	0.0000	6	-0.0177	-0.0177	0.0000
7	-0.0250	-0.0000	0.0000	0.0000	7	-0.0250	-0.0000	0.0000
8	-0.0177	-0.0177	0.0000	0.0000	8	-0.0177	-0.0177	0.0000
9	-0.0000	-0.0250	0.0000	0.0000	9	-0.0000	-0.0250	0.0000
10	0.0000	-0.0250	0.0000	0.0000	10	0.0000	-0.0250	0.0000
11	-0.0530	-0.0530	0.0000	0.0000	11	-0.0530	-0.0530	0.0000
12	-0.0530	-0.0530	0.0000	0.0000	12	-0.0530	-0.0530	0.0000
13	-0.0530	-0.0530	0.0000	0.0000	13	-0.0530	-0.0530	0.0000
14	-0.0000	-0.0530	0.0000	0.0000	14	-0.0000	-0.0530	0.0000
15	0.0000	-0.0530	0.0000	0.0000	15	0.0000	-0.0530	0.0000
16	-0.0325	-0.0675	0.0000	0.0000	16	-0.0325	-0.0675	0.0000
17	-0.0542	-0.0675	0.0000	0.0000	17	-0.0542	-0.0675	0.0000
18	-0.0731	-0.0675	0.0000	0.0000	18	-0.0731	-0.0675	0.0000
19	-0.0731	-0.0675	0.0000	0.0000	19	-0.0731	-0.0675	0.0000
20	-0.0542	-0.0675	0.0000	0.0000	20	-0.0542	-0.0675	0.0000
21	-0.0325	-0.0675	0.0000	0.0000	21	-0.0325	-0.0675	0.0000
22	-0.0000	-0.0675	0.0000	0.0000	22	-0.0000	-0.0675	0.0000
23	0.0000	-0.0675	0.0000	0.0000	23	0.0000	-0.0675	0.0000
24	-0.0542	-0.1126	0.0000	0.0000	24	-0.0542	-0.1126	0.0000
25	-0.0977	-0.1126	0.0000	0.0000	25	-0.0977	-0.1126	0.0000
26	-0.1219	-0.1126	0.0000	0.0000	26	-0.1219	-0.1126	0.0000
27	-0.1219	-0.1126	0.0000	0.0000	27	-0.1219	-0.1126	0.0000
28	-0.0977	-0.1126	0.0000	0.0000	28	-0.0977	-0.1126	0.0000
29	-0.0542	-0.1126	0.0000	0.0000	29	-0.0542	-0.1126	0.0000
30	-0.0000	-0.1126	0.0000	0.0000	30	-0.0000	-0.1126	0.0000

ELEMENT 1 2 3 4 XC YC ZC RC YC AREA

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524
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STEP	1 COMPLETE.CP	TIME FOR STEP IS	.32300
STEP	2 COMPLETE.CP	TIME FOR STEP IS	.57700
STEP	3 COMPLETE.CP	TIME FOR STEP IS	.82000
STEP	4 COMPLETE.CP	TIME FOR STEP IS	1.16300
STEP	5 COMPLETE.CP	TIME FOR STEP IS	1.06300
STEP	6 COMPLETE.CP	TIME FOR STEP IS	2.15100
STEP	7 COMPLETE.CP	TIME FOR STEP IS	2.42700
STEP	8 COMPLETE.CP	TIME FOR STEP IS	2.42000
STEP	9 COMPLETE.CP	TIME FOR STEP IS	2.35100
STEP	10 COMPLETE.CP	TIME FOR STEP IS	1.99100
STEP	11 COMPLETE.CP	TIME FOR STEP IS	1.31400
STEP	12 COMPLETE.CP	TIME FOR STEP IS	1.83900

[illegible]

```
STEP 2 DEPTH = .0250000 TIME = .0001991 DIMENSIONLESS TIME .0796345 WETTING FACTOR = 1.4500380
```

[illegible]

```
STEP      3      DEPTH = .0375000      TIME = .0002996      DIMENSIONLESS TIME      .1194510      WETTING FACTOR = 1.4588000
```

NO.	REF.NO.	MOD	AREA	X	Y	Z	T ₀	C ₀	P	FORCE
1	4	1	.6595E+05	.0524E+1	-.0511	.000000	.0016	10.40	.1088E+06	.6559E+00
1	4	1	.7377E+03	.0193E+0	-.05489	.000000	.0135	7.85	.7619E+05	.5629E+02
2	5	1	.6717E+03	.0905E+0	-.05312	.000000	.0148	6.44	.6246E+05	.4230E+02
3	10	1	.6717E+03	.0905E+0	-.05312	.000000	.0148	6.44	.6246E+05	.4230E+02
4	11	2	.2156E+02	.0620E+3	.0779E	.000000	.0046	4.30	.4248E+05	.9159E+02
5	12	2	.2156E+02	.0620E+3	.0779E	.000000	.0046	4.30	.4248E+05	.9159E+02
5	12	2	.2156E+02	.0620E+3	.0779E	.000000	.0046	4.30	.4248E+05	.9159E+02

13 - US - 6N 6W 50LE0115
14 - 6N 6W 50LE0115
15 - 6N 6W 50LE0115
16 - 6N 6W 50LE0115
17 - 6N 6W 50LE0115
18 - 6N 6W 50LE0115
19 - 6N 6W 50LE0115
20 - 6N 6W 50LE0115
21 - 6N 6W 50LE0115
22 - 6N 6W 50LE0115
23 - 6N 6W 50LE0115
24 - 6N 6W 50LE0115
25 - 6N 6W 50LE0115
26 - 6N 6W 50LE0115
27 - 6N 6W 50LE0115
28 - 6N 6W 50LE0115
29 - 6N 6W 50LE0115
30 - 6N 6W 50LE0115
31 - 6N 6W 50LE0115
32 - 6N 6W 50LE0115
33 - 6N 6W 50LE0115
34 - 6N 6W 50LE0115
35 - 6N 6W 50LE0115
36 - 6N 6W 50LE0115
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100 - 6N 6W 50LE0115

FX = 0.000000 CD = 1.0753206 CN = .0000000 MX = .3242845 MY = 0.000000 MZ = 0.0000000

STEP 4 DEPTH = .0500000 TIME = .0003042 DIMENSIONLESS TIME .1592690 WETTING FACTOR = 1.4500000

NO.	OFF.NO.	MOD	AREA	X	Y	Z	T*	CP	P	FORCE
1	4	1	.5557E-03	.047559	.034344	.000000	.0149	7.31	.7095E+05	.3943E+02
2	5	2	.1676E-02	.019420	.047527	.000000	.0350	5.74	.5603E+05	.9392E+02
3	9	1	.1736E-04	.117755	.025424	.000000	.0015	11.59	.1124E+06	.1952E+01
4	10	2	.2001E-02	.090150	.044940	.000000	.0314	5.12	.4970E+05	.9947E+02
5	11	0	.2149E-02	.062802	.077811	.000000	.0941	2.94	.2086E+05	.6261E+02
6	12	0	.2149E-02	.022146	.097024	.000000	.1147	2.60	.2520E+05	.5468E+02

FX = 0.0000000 CD = .7041272E-03 FN = .5949187E-07 SMX = .4103236F+02 SMY = 0.0000000 MZ = 0.0000000

STEP 5 DEPTH = .0625000 TIME = .0004977 DIMENSIONLESS TIME .1990463 WETTING FACTOR = 1.4500000

NO.	OFF.NO.	MOD	AREA	X	Y	Z	T*	CP	P	FORCE
1	1	1	.0859E-03	.089423	.004722	.000000	.0155	4.07	.7823E+05	.3176E+02
2	4	0	.1768E-02	.046234	.014151	.000000	.0305	5.21	.5056E+05	.8937E+02
3	5	0	.1748E-02	.019151	.046234	.000000	.0736	3.70	.3680E+05	.6505E+02
4	9	1	.1045E-02	.099524	.011350	.000000	.0181	6.39	.6201E+05	.6726E+02
5	10	0	.2169E-02	.084448	.043182	.000000	.0688	3.27	.3173E+05	.6883E+02
6	11	0	.2169E-02	.062852	.077811	.000000	.1230	2.43	.2359E+05	.5117E+02
7	12	0	.2169E-02	.022146	.097024	.000000	.1545	2.23	.2161E+05	.4680E+02

FX = 0.0000000 CD = .8406484E+03 FN = .7101335E-07 SMX = .3459912E+02 SMY = 0.0000000 MZ = 0.0000000

STEP 6 DEPTH = .0750000 TIME = .0005973 DIMENSIONLESS TIME .2309036 WETTING FACTOR = 1.4500000

NO.	OFF.NO.	MOD	AREA	X	Y	Z	T*	CP	P	FORCE
1	1	0	.8119E-03	.089423	.000000	.000000	.0394	5.09	.4974E+05	.4806E+02
2	2	1	.9153E-04	.014226	.022559	.000000	.0039	10.83	.1650E+06	.9613E+01
3	3	2	.1212E-02	.045427	.012185	.000000	.0204	7.33	.7107E+05	.8614E+02
4	4	0	.1768E-02	.046234	.014151	.000000	.0703	3.84	.3768E+05	.6646E+02
5	5	0	.1768E-02	.019151	.046234	.000000	.1135	3.04	.2947E+05	.5210E+02
6	8	1	.1679E-03	.083923	.022230	.000000	.0044	10.26	.9954E+05	.1672E+02
7	9	2	.2152E-02	.099377	.000209	.000000	.0402	4.96	.4310E+05	.1035E+03
8	10	0	.2169E-02	.089468	.043182	.000000	.1084	2.52	.2449E+05	.5312E+02
9	11	0	.2169E-02	.062852	.077811	.000000	.1637	2.04	.2026E+05	.4396E+02
10	12	0	.2169E-02	.022146	.097024	.000000	.1944	1.94	.1899E+05	.4121E+02

FX = 0.0000000 CD = .1025785E+04 FN = .0665847E-07 SMX = .7355449F+02 SMY = 0.0000000 MZ = 0.0000000

STEP 7 DEPTH = .0875000 TIME = .0006959 DIMENSIONLESS TIME .2707208 WETTING FACTOR = 1.4500000

NO.	OFF.NO.	MOD	AREA	X	Y	Z	T*	CP	P	FORCE
1	1	0	.8119E-03	.089423	.000000	.000000	.0796	3.90	.3707E+05	.3075E+02
2	2	1	.1020E-02	.018900	.027735	.000000	.0200	7.19	.6972E+05	.7175E+02
3	3	2	.1741E-02	.046211	.019033	.000000	.0493	5.40	.5239E+05	.9226E+02
4	4	0	.1768E-02	.046234	.014151	.000000	.1101	3.03	.2941E+05	.5199E+02
5	5	0	.1768E-02	.019151	.046234	.000000	.1533	2.57	.2490E+05	.4401E+02
6	7	1	.1315E-04	.054637	.044921	.000000	.0017	12.02	.1166E+06	.1533E+01
7	8	2	.1492E-02	.089274	.027861	.000000	.0225	6.35	.6160E+05	.9192E+02
8	9	0	.2169E-02	.099424	.000000	.000000	.0796	3.01	.2922E+05	.6339E+02
9	10	0	.2169E-02	.089468	.043182	.000000	.1484	2.09	.2027E+05	.4397E+02
10	11	0	.2169E-02	.062852	.077811	.000000	.2036	1.03	.1778E+05	.3050E+02
11	12	0	.2169E-02	.022146	.097024	.000000	.2342	1.74	.1692E+05	.3670E+02

FX = 0.0000000 CD = .1133786E+04 FN = .0577343E-07 SMX = .7357570E+02 SMY = 0.0000000 MZ = 0.0000000

STEP 8 DEPTH = .1000000 TIME = .0007463 DIMENSIONLESS TIME .3105301 WETTING FACTOR = 1.4500000

NO.	OFF.NO.	MOD	AREA	X	Y	Z	T*	CP	P	FORCE
1	1	0	.8119E-03	.089423	.000000	.000000	.0796	3.90	.3707E+05	.3075E+02
2	2	1	.1020E-02	.018900	.027735	.000000	.0200	7.19	.6972E+05	.7175E+02
3	3	2	.1741E-02	.046211	.019033	.000000	.0493	5.40	.5239E+05	.9226E+02
4	4	0	.1768E-02	.046234	.014151	.000000	.1101	3.03	.2941E+05	.5199E+02
5	5	0	.1768E-02	.019151	.046234	.000000	.1533	2.57	.2490E+05	.4401E+02
6	7	1	.1315E-04	.054637	.044921	.000000	.0017	12.02	.1166E+06	.1533E+01
7	8	2	.1492E-02	.089274	.027861	.000000	.0225	6.35	.6160E+05	.9192E+02
8	9	0	.2169E-02	.099424	.000000	.000000	.0796	3.01	.2922E+05	.6339E+02
9	10	0	.2169E-02	.089468	.043182	.000000	.1484	2.09	.2027E+05	.4397E+02
10	11	0	.2169E-02	.062852	.077811	.000000	.2036	1.03	.1778E+05	.3050E+02
11	12	0	.2169E-02	.022146	.097024	.000000	.2342	1.74	.1692E+05	.3670E+02

NO. REF. NO. MOD AREA X Y Z T_o CP P FORCE
 1 1 0 -0119E-03 -009623 -000000 -000000 -0.119E-03 2.9A .280E+05 .2345E+02
 2 2 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 4.29 .4159E+05 .7353E+02
 3 3 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 3.39 .3204E+05 .5089E+02
 4 4 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 2.58 .2408E+05 .4257E+02
 5 5 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 2.20 .2139E+05 .3766E+02
 6 6 1 -0119E-02 -009623 -000000 -000000 -0.45E-02 12.12 .1176E+06 .1577E+02
 7 7 1 -0119E-02 -009623 -000000 -000000 -0.45E-02 7.19 .6973E+05 .6639E+02
 8 8 2 -0119E-02 -009623 -000000 -000000 -0.45E-02 4.53 .4394E+05 .9504E+02
 9 9 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 2.18 .2119E+05 .4578E+02
 10 10 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.79 .1733E+05 .3759E+02
 11 11 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.61 .1567E+05 .3398E+02
 12 12 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.55 .1504E+05 .3267E+02

FX = 0. FD = -0.112501E+04 FM = -0.950512E-07 SMX = -0.817067E+01 SMY = 0. SMZ = 0.
 CY = 0. CD = -0.34280937 CN = -0.000000 MX = -0.0684431 MY = 0. MZ = 0.0000000

STEP 9 DEPTH = .1125000 TIME = .0000059 DIMENSIONLESS TIME .3583553 WETTING FACTOR = 1.4500000

NO. REF. NO. MOD AREA X Y Z T_o CP P FORCE
 1 1 0 -0119E-03 -009623 -000000 -000000 -0.119E-03 2.41 .2334E+05 .1095E+02
 2 2 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 3.40 .3290E+05 .5831E+02
 3 3 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 2.56 .2401E+05 .4304E+02
 4 4 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 2.07 .2000E+05 .3549E+02
 5 5 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.90 .1840E+05 .3252E+02
 6 6 1 -0119E-02 -009623 -000000 -000000 -0.45E-02 6.76 .6560E+05 .7791E+02
 7 7 2 -0119E-02 -009623 -000000 -000000 -0.45E-02 5.35 .5192E+05 .1055E+03
 8 8 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 2.51 .2433E+05 .5285E+02
 9 9 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.75 .1690E+05 .3689E+02
 10 10 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.54 .1490E+05 .3233E+02
 11 11 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.42 .1379E+05 .2992E+02
 12 12 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.34 .1339E+05 .2904E+02

FX = 0. FD = -0.1107051E+04 FM = -0.935378E-07 SMX = -0.230766E+02 SMY = 0. SMZ = 0.
 CY = 0. CD = -0.3751276 CN = -0.000000 MX = -0.1980611 MY = 0. MZ = 0.0000000

STEP 10 DEPTH = .1250000 TIME = .0000054 DIMENSIONLESS TIME .3981776 WETTING FACTOR = 1.4500000

NO. REF. NO. MOD AREA X Y Z T_o CP P FORCE
 1 1 0 -0119E-03 -009623 -000000 -000000 -0.119E-03 1.04 .1804E+05 .1465E+02
 2 2 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 2.27 .2201E+05 .3091E+02
 3 3 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.89 .1836E+05 .3244E+02
 4 4 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.67 .1628E+05 .2864E+02
 5 5 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.50 .1534E+05 .2712E+02
 6 6 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 3.34 .3230E+05 .7026E+02
 7 7 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 2.33 .2264E+05 .4911E+02
 8 8 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.63 .1580E+05 .3429E+02
 9 9 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.39 .1347E+05 .2923E+02
 10 10 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.28 .1244E+05 .2708E+02
 11 11 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.21 .1178E+05 .2555E+02
 12 12 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.19 .1155E+05 .2505E+02

FX = 0. FD = -0.045298E+03 FM = -0.670756E-07 SMX = -0.143030E+02 SMY = 0. SMZ = 0.
 CY = 0. CD = -0.6497432 CN = -0.000000 MX = -0.1201697 MY = 0. MZ = 0.0000000

STEP 11 DEPTH = .1375000 TIME = .0010050 DIMENSIONLESS TIME .4379899 WETTING FACTOR = 1.4500000

NO. REF. NO. MOD AREA X Y Z T_o CP P FORCE
 1 1 0 -0119E-03 -009623 -000000 -000000 -0.119E-03 1.51 .1443E+05 .1108E+02
 2 2 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.57 .1521E+05 .2689E+02
 3 3 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.49 .1444E+05 .2554E+02
 4 4 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.41 .1370E+05 .2422E+02
 5 5 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.37 .1332E+05 .2354E+02
 6 6 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.62 .1578E+05 .3406E+02
 7 7 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.41 .1369E+05 .2971E+02
 8 8 0 -0119E-02 -009623 -000000 -000000 -0.45E-02 1.20 .1237E+05 .2406E+02

[illegible]

EXAMPLE 2
*****PROGRAM OPTIONS*****
CONSTANT BODY ORIENTATION
DO NOT PRINT
SYMMETRIC CONFIGURATION

*****PROBLEM PARAMETERS*****

DIAMETER 1-2000 FT
ENTRY VELOCITY 100.000 (FT/SEC)
BODY ORIENTATION ANGLE 70.00 DEGREES
INITIAL DEPTH .47814 FT TERMINATION STEP 1
INITIAL PRESSURE CORRECTION FACTOR = .6700
CENTROIDE COORDINATES 0.0000 0.0000 0.0000
INCREMENT IN DEPTH .0290050
ANGLE OF ATTACK 20.00
YAW ANGLE 0.00

WETTING FACTORS

1-.35931
1-.11317

*****GRID OPTIONS*****
06IVE

SYMMETRY = 0
BODY PROFILE

R Z
0.00000 0.00000
.250000 .250000
1.000000 1.000000
GRID SIZE
H B NUMBER
.100000 70.000000 8
.200000 70.000000 8
.300000 70.000000 8
.400000 70.000000 8
.500000 70.000000 8
.600000 70.000000 8
.700000 70.000000 8
.800000 70.000000 8
.900000 70.000000 8
1.000000 70.000000 8

MODE	X	Y	Z	XP	YP	ZP
1	0.0000	-.0001	-.0001	0.0000	-.0001	-.4700
2	-.0000	-.0001	-.0001	-.0000	-.0001	-.4700
3	-.0001	-.0001	-.0001	-.0001	-.0000	-.4700
4	-.0001	-.0000	-.0001	-.0001	-.0000	-.4700
5	-.0001	-.0000	-.0001	-.0001	-.0000	-.4700
6	-.0001	-.0000	-.0001	-.0001	-.0001	-.4701
7	-.0001	-.0001	-.0001	-.0001	-.0001	-.4701
8	-.0000	-.0001	-.0001	-.0000	-.0001	-.4701
9	-.0000	-.0001	-.0001	-.0000	-.0001	-.4701
10	0.0000	-.0466	-.0466	0.0000	-.0279	-.4184
11	-.0182	-.0448	-.0476	-.0182	-.0250	-.4184
12	-.0358	-.0358	-.0506	-.0358	-.0163	-.4184
13	-.0516	-.0214	-.0550	-.0516	-.0010	-.4184
14	-.0636	-.0000	-.0636	-.0636	-.0218	-.4184
15	-.0683	-.0283	-.0739	-.0683	-.0518	-.4184
16	-.0606	-.0606	-.0606	-.0606	-.0662	-.4184
17	-.0367	-.0095	-.0958	-.0367	-.1160	-.4184
18	-.0000	-.1000	-.1000	-.0000	-.1242	-.4184
19	0.0000	-.0933	-.0933	0.0000	-.0557	-.3506
20	-.0364	-.0879	-.0952	-.0364	-.0501	-.3506
21	-.0715	-.0715	-.1012	-.0715	-.0326	-.3506

22	.1032	-.0427	.1117	.1032	-.0020	-.3586
23	.1272	.0070	.1272	.1272	.0435	-.3586
24	.1465	.0566	.1478	.1365	.1037	-.3586
25	.211	.1211	.1713	.1211	.1724	-.3586
26	.0733	.1771	.1917	.0733	.2319	-.3586
27	.0000	.2009	.2000	.0000	.2563	-.3586
28	.0000	.1399	.1399	0.0000	-.0036	-.2488
29	.0546	.1319	.1428	.0546	-.0751	-.2488
30	.1073	.1073	.518	.1073	-.0489	-.2488
31	.1547	-.0641	.1675	.1547	-.0029	-.2488
32	.1908	.0000	.1908	.1908	.0653	-.2488
33	.2348	.0848	.2217	.2044	.1555	-.2488
34	.1917	.1817	.2569	.1817	.2586	-.2488
35	.1100	.2656	.2475	.1100	.3479	-.2488
36	.0000	.7000	.3000	.0000	.3845	-.2488
37	.0000	-.1865	.1865	0.0000	.1115	-.2391
38	.0729	-.1759	.1904	.0729	-.1002	-.2391
39	.1431	-.1431	.2023	.1431	-.0652	-.2391
40	.2043	-.0955	.2233	.2063	-.0039	-.2391
41	.2544	.0000	.2544	.2544	.0870	-.2391
42	.2731	.1131	.2456	.2731	.2074	-.2391
43	.2422	.2422	.3426	.2422	.3448	-.2391
44	.1467	.3541	.3833	.1457	.4639	-.2391
45	.0000	.4000	.4000	.0000	.5127	-.2391
46	.0000	-.2332	.2332	0.0000	-.1393	-.1793
47	.0911	-.2199	.2380	.0911	-.1252	-.1793
48	.1748	-.1788	.2529	.1768	-.0416	-.1793
49	.2579	-.1068	.2791	.2579	-.0049	-.1793
50	.3140	.0000	.3180	.3180	.1088	-.1793
51	.3414	.1414	.3695	.3414	.2552	-.1793
52	.3028	.3028	.4282	.3028	.4310	-.1793
53	.1834	.4427	.4791	.1834	.5798	-.1793
54	.0000	.5000	.5000	.0000	.6409	-.1793
55	.0000	-.2798	.2798	0.0000	-.1472	-.1195
56	.1093	-.2638	.2856	.1093	.1503	-.1195
57	.2146	-.2146	.3035	.2146	-.0979	-.1195
58	.3095	-.1282	.3350	.3095	-.0059	-.1195
59	.3816	.0000	.3816	.3816	.1385	-.1195
60	.4096	.1697	.4434	.4096	.3111	-.1195
61	.3634	.3634	.5139	.3634	.5172	-.1195
62	.2200	.5312	.5759	.2200	.6958	-.1195
63	.0000	.6000	.6000	.0000	.7690	-.1195
64	.0000	-.3264	.3264	0.0000	-.1951	-.0598
65	.1275	-.3978	.3332	.1275	-.1753	-.0598
66	.2504	-.2504	.3541	.2504	-.1142	-.0598
67	.3610	-.1495	.3908	.3610	-.0069	-.0598
68	.4452	.0000	.4452	.4452	.1523	-.0598
69	.4779	.1980	.5173	.4779	.3629	-.0598
70	.4219	.4239	.5995	.4239	.6034	-.0598
71	.2567	.6197	.6708	.2567	.8118	-.0598
72	.0000	.7000	.7000	.0000	.9972	-.0598
73	.0000	-.3730	.3730	0.0000	-.2230	-.0000
74	.1457	-.3518	.3608	.1457	-.2003	-.0000
75	.2861	-.2861	.4047	.2861	-.1305	-.0000
76	.4126	-.1709	.4466	.4126	-.0079	-.0000
77	.5088	.0000	.5088	.1740	-.0000	-.0000
78	.5462	.2262	.5912	.5462	.4148	-.0000
79	.4845	.4845	.6852	.4845	.6496	-.0000
80	.2934	.7083	.7666	.2934	.9277	-.0000
81	.0000	.8000	.8000	.0000	1.0254	-.0000
82	.0000	-.4197	.4197	0.0000	-.2508	-.0598
83	.1639	.7958	.4284	.1639	-.2254	-.0598
84	.3219	-.3219	.4553	.3219	-.1468	-.0598
85	.4642	-.1923	.5024	.4642	-.0084	-.0598
86	.5724	.0000	.5724	.5724	.1958	-.0598
87	.6144	.2545	.6451	.6144	.4666	-.0598

ELEMENT	AREA									
	1	2	3	4	XC	YC	ZC	RC	TC	AREA
88	5450	5450	7708	5450	7758	0598				
89	3300	7968	8624	3300	16437	0598				
90	9000	9000	9000	9000	11535	0598				
91	0000	4663	0000	0000	2787	1195				
92	1821	4397	4760	1821	2504	1195				
93	3577	3577	5058	3577	1631	1195				
94	5154	5563	5154	5154	8098	1195				
95	6360	6000	6360	6360	2175	1195				
96	6827	7390	6827	6827	5185	1195				
97	6056	6056	8565	6056	1197	1195				
98	3667	8853	9583	3667	11597	1195				
99	10000	10000	10000	10000	12817	1195				
100	168633	168633	168633	168633	03081	03141	03210	03273	03347	03419
101	15903	15903	15903	15903	03210	03273	03347	03419	03491	03563
102	123189	123189	123189	123189	03491	03563	03636	03709	03781	03854
103	100508	100508	100508	100508	03709	03854	03928	04001	04074	04147
104	77897	77897	77897	77897	04074	04147	04220	04293	04366	04439
105	55411	55411	55411	55411	04220	04293	04366	04439	04512	04585
106	33111	33111	33111	33111	04439	04512	04585	04658	04731	04804
107	11007	11007	11007	11007	04658	04731	04804	04877	04950	05023
108	168633	168633	168633	168633	04877	04950	05023	05096	05169	05242
109	145903	145903	145903	145903	05096	05169	05242	05315	05388	05461
110	123189	123189	123189	123189	05315	05388	05461	05534	05607	05680
111	100508	100508	100508	100508	05534	05607	05680	05753	05826	05899
112	77897	77897	77897	77897	05753	05826	05899	05972	06045	06118
113	55411	55411	55411	55411	05972	06045	06118	06191	06264	06337
114	33111	33111	33111	33111	06118	06191	06264	06337	06410	06483
115	11007	11007	11007	11007	06337	06410	06483	06556	06629	06702
116	168633	168633	168633	168633	06556	06629	06702	06775	06848	06921
117	145903	145903	145903	145903	06775	06848	06921	06994	07067	07140
118	123189	123189	123189	123189	06994	07067	07140	07213	07286	07359
119	100508	100508	100508	100508	07213	07286	07359	07432	07505	07578
120	77897	77897	77897	77897	07432	07505	07578	07651	07724	07797
121	55411	55411	55411	55411	07651	07724	07797	07870	07943	08016
122	33111	33111	33111	33111	07870	07943	08016	08089	08162	08235
123	11007	11007	11007	11007	08016	08089	08162	08235	08308	08381
124	168633	168633	168633	168633	08235	08308	08381	08454	08527	08600
125	145903	145903	145903	145903	08454	08527	08600	08673	08746	08819
126	123189	123189	123189	123189	08673	08746	08819	08892	08965	09038
127	100508	100508	100508	100508	08892	08965	09038	09111	09184	09257
128	77897	77897	77897	77897	09111	09184	09257	09330	09403	09476
129	55411	55411	55411	55411	09330	09403	09476	09549	09622	09695
130	33111	33111	33111	33111	09549	09622	09695	09768	09841	09914
131	11007	11007	11007	11007	09768	09841	09914	09987	10060	10133
132	168633	168633	168633	168633	09987	10060	10133	10206	10279	10352
133	145903	145903	145903	145903	10206	10279	10352	10425	10498	10571
134	123189	123189	123189	123189	10425	10498	10571	10644	10717	10790
135	100508	100508	100508	100508	10644	10717	10790	10863	10936	11009
136	77897	77897	77897	77897	10863	10936	11009	11082	11155	11228
137	55411	55411	55411	55411	11082	11155	11228	11301	11374	11447
138	33111	33111	33111	33111	11301	11374	11447	11520	11593	11666
139	11007	11007	11007	11007	11520	11593	11666	11739	11812	11885
140	168633	168633	168633	168633	11739	11812	11885	11958	12031	12104
141	145903	145903	145903	145903	11958	12031	12104	12177	12250	12323
142	123189	123189	123189	123189	12177	12250	12323	12396	12469	12542
143	100508	100508	100508	100508	12396	12469	12542	12615	12688	12761
144	77897	77897	77897	77897	12615	12688	12761	12834	12907	13000
145	55411	55411	55411	55411	12834	12907	13000	13073	13146	13219
146	33111	33111	33111	33111	13073	13146	13219	13292	13365	13438
147	11007	11007	11007	11007	13292	13365	13438	13511	13584	13657
148	168633	168633	168633	168633	13511	13584	13657	13730	13803	13876
149	145903	145903	145903	145903	13730	13803	13876	13949	14022	14095
150	123189	123189	123189	123189	13949	14022	14095	14168	14241	14314
151	100508	100508	100508	100508	14168	14241	14314	14387	14460	14533
152	77897	77897	77897	77897	14387	14460	14533	14606	14679	14752
153	55411	55411	55411	55411	14606	14679	14752	14825	14898	14971
154	33111	33111	33111	33111	14825	14898	14971	15044	15117	15190
155	11007	11007	11007	11007	15044	15117	15190	15263	15336	15409
156	168633	168633	168633	168633	15263	15336	15409	15482	15555	15628
157	145903	145903	145903	145903	15482	15555	15628	15701	15774	15847
158	123189	123189	123189	123189	15701	15774	15847	15920	15993	16066
159	100508	100508	100508	100508	15920	15993	16066	16139	16212	16285
160	77897	77897	77897	77897	16139	16212	16285	16358	16431	16504
161	55411	55411	55411	55411	16358	16431	16504	16577	16650	16723
162	33111	33111	33111	33111	16577	16650	16723	16796	16869	16942
163	11007	11007	11007	11007	16796	16869	16942	17015	17088	17161
164	168633	168633	168633	168633	17015	17088	17161	17234	17307	17380
165	145903	145903	145903	145903	17234	17307	17380	17453	17526	17599
166	123189	123189	123189	123189	17453	17526	17599	17672	17745	17818
167	100508	100508	100508	100508	17672	17745	17818	17891	17964	18037
168	77897	77897	77897	77897	17891	17964	18037	18110	18183	18256
169	55411	55411	55411	55411	18110	18183	18256	18329	18402	18475
170	33111	33111	33111	33111	18329	18402	18475	18548	18621	18694
171	11007	11007	11007	11007	18548	18621	18694	18767	18840	18913
172	168633	168633	168633	168633	18767	18840	18913	18986	19059	19132
173	145903	145903	145903	145903	18986	19059	19132	19205	19278	19351
174	123189	123189	123189	123189	19205	19278	19351	19424	19497	19570
175	100508	100508	100508	100508	19424	19497	19570	19643	19716	19789
176	77897	77897	77897	77897	19643	19716	19789	19862	19935	20008
177	55411	55411	55411	55411	19862	19935	20008	20081	20154	20227
178	33111	33111	33111	33111	20081	20154	20227	20300	20373	20446
179	11007	11007	11007	11007	20300	20373	20446	20519	20592	20665
180	168633	168633	168633	168633	20519	20592	20665	20738	20811	20884
181	145903	145903	145903	145903	20738	20811	20884	20957	21030	21103
182	123189	123189	123189	123189	20957	21030	21103	21176	21249	21322
183	100508	100508	100508	100508	21176	21249	21322	21395	21468	21541
184	77897	77897	77897	77897	21395	21468	21541	21614	21687	21760
185	55411	55411	55411	55411	21614	21687	21760	21833	21906	21979
186	33111	33111	33111	33111	21833	21906	21979	22052	22125	22198
187	11007	11007	11007	11007	22052	22125	22198	22271	22344	22417
188	168633	168633	168633	168633	22271	22344	22417	22490	22563	22636
189	145903	145903	145903	145903	22490	22563	22636	22709	22782	22855
190	123189	123189	123189	123189	22709	22782	22855	22928	23001	23074
191	100508	100508	100508	100508	23001	23074	23147	23220	23293	23366
192	77897	77897	77897	77897	23220	23293	23366	23439	23512	23585
193	55411	55411	55411	55411	23439	23512	23585	23658	23731	23804
194	33111	33111	33111	33111	23658	23731	23804	23877	23950	24023
195	11007	11007	11007	11007	23877	23950	24023	24096	24169	24242
196	168633	168633	168633	168633	24096	24169	24242	24315	24388	24461
197	145903	145903	145903	145903	24315	24388	24461	24534	24607	24680
198	123189	123189	123189	123189	24534	24607	24680	24753	24826	24899
199	100508	1005								

STEP	NO.	REF. NO.	2	DEPTH	AREA	X	Y	Z	TIME	DIMENSIONLESS TIME	CP	P	FORCE	WETTING FACTOR
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	9	0	0	0	0	0	0	0	0	0	0	0	0	0
10	10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	11	0	0	0	0	0	0	0	0	0	0	0	0	0
12	12	0	0	0	0	0	0	0	0	0	0	0	0	0
13	13	0	0	0	0	0	0	0	0	0	0	0	0	0
14	14	0	0	0	0	0	0	0	0	0	0	0	0	0
15	15	0	0	0	0	0	0	0	0	0	0	0	0	0
16	16	0	0	0	0	0	0	0	0	0	0	0	0	0
17	17	0	0	0	0	0	0	0	0	0	0	0	0	0
18	18	0	0	0	0	0	0	0	0	0	0	0	0	0
19	19	0	0	0	0	0	0	0	0	0	0	0	0	0
20	20	0	0	0	0	0	0	0	0	0	0	0	0	0
21	21	0	0	0	0	0	0	0	0	0	0	0	0	0
22	22	0	0	0	0	0	0	0	0	0	0	0	0	0
23	23	0	0	0	0	0	0	0	0	0	0	0	0	0
24	24	0	0	0	0	0	0	0	0	0	0	0	0	0
25	25	0	0	0	0	0	0	0	0	0	0	0	0	0
26	26	0	0	0	0	0	0	0	0	0	0	0	0	0
27	27	0	0	0	0	0	0	0	0	0	0	0	0	0

STEP

STEP

STEP

28	28	0	.6792E-02	.202937	-.037642	.218424	.2135	.98	.9459E+04	.6425E+02	0.	0.0000000	FD = .2511962E+05	FM = .1666419E+05	SNZ = 0.	SMZ = 0.							
29	29	0	.8990E-02	.232349	.049824	.242259	.2135	1.26	.1223E+05	.1099E+03	0.	0.0000000	CD = 2.2898635	CN = 1.5190882	MX = 1.5761388	MZ = 0.0000000							
30	30	0	.1211E-01	.226988	.156526	.281895	.2135	1.64	.1598E+05	.1924E+03	0.	0.0000000	DEPTM = .5370502	TIME = .0051418	DIMENSIONLESS TIME	.4284818	WETTING FACTOR = 1.1131710						
31	31	0	.1578E-01	.171312	.262685	.319734	.2135	2.01	.1950E+05	.3061E+03	0.	0.0000000	REF. NO.	MOD	AREA	X	Y	Z	T*	CP	P	FORCE	
32	32	0	.1033E-01	.064611	.332175	.345826	.2135	2.24	.2177E+05	.3991E+03	0.	0.0000000	1	0	.6065E-03	.006072	-.030202	.031410	.3968	.68	.6629E+04	.4021E+01	
33	33	0	.5459E-02	.041152	-.204701	.212886	.1747	.73	.7071E+04	.3068E+02	0.	0.0000000	2	0	.6578E-03	.017995	-.026581	.032727	.3968	.62	.5972E+04	.3929E+01	
34	34	0	.5921E-02	.121962	-.100168	.221818	.1747	.75	.7249E+04	.4293E+02	0.	0.0000000	3	0	.9703E-03	.029115	-.019844	.035471	.3968	.56	.5429E+04	.4190E+01	
35	35	0	.6945E-02	.197337	-.129877	.249411	.1747	.82	.7998E+04	.5555E+02	0.	0.0000000	4	0	.1204E-02	.043958	.009426	.045833	.3968	.62	.5973E+04	.5794E+01	
36	36	0	.7338E-02	.260223	-.040267	.269823	.1747	1.01	.9825E+04	.8508E+02	0.	0.0000000	5	0	.1729E-02	.042944	.029613	.053190	.3968	1.16	.1123E+05	.1944E+02	
37	37	0	.1156E-01	.297937	.063889	.316645	.1747	1.34	.1296E+05	.1498E+03	0.	0.0000000	6	0	.2243E-02	.032410	.049697	.060490	.3968	1.48	.1439E+05	.3227E+02	
38	38	0	.1556E-01	.291862	.200718	.368444	.1747	1.76	.1707E+05	.2657E+03	0.	0.0000000	7	0	.2619E-02	.061224	.062844	.065275	.3968	1.68	.1634E+05	.4270E+02	
39	39	0	.2018E-01	.219670	.336837	.409990	.1747	2.18	.2113E+05	.4265E+03	0.	0.0000000	8	0	.1020E-02	.014167	-.070471	.073209	.3545	60	.6601E+04	.1201E+03	
40	40	0	.2357E-01	.082849	.425942	.442421	.1747	2.45	.2372E+05	.5598E+03	0.	0.0000000	9	0	.1974E-02	.041987	-.062022	.072364	.3545	.65	.6264E+04	.1234E+02	
41	41	0	.6672E-02	.050229	-.249851	.259842	.1359	.70	.6768E+04	.4510E+02	0.	0.0000000	10	0	.2315E-02	.067936	-.044436	.082764	.3545	.73	.6176E+04	.1428E+02	
42	42	0	.7237E-02	.148863	-.211987	.270744	.1359	.73	.7088E+04	.5124E+02	0.	0.0000000	11	0	.2911E-02	.089585	-.016617	.092890	.3545	.64	.7804E+04	.2852E+02	
43	43	0	.8498E-02	.240863	-.157547	.293437	.1359	.83	.8086E+04	.6864E+02	0.	0.0000000	12	0	.3053E-02	.102568	.102568	.106943	.3545	.95	.9224E+04	.3554E+02	
44	44	0	.1067E-01	.317619	-.058913	.329337	.1359	1.06	.1027E+05	.1096E+03	0.	0.0000000	13	0	.5108E-02	.100202	.069097	.124087	.3545	1.27	.1232E+05	.6393E+02	
45	45	0	.1413E-01	.363651	-.077980	.379163	.1359	1.43	.1389E+05	.1962E+03	0.	0.0000000	14	0									
46	46	0	.1902E-01	.355261	-.244980	.439945	.1359	1.92	.1862E+05	.3542E+03	0.	0.0000000											
47	47	0	.2467E-01	.268122	.411132	.508420	.1359	2.41	.2334E+05	.5759E+03	0.	0.0000000											
48	48	0	.2888E-01	.101123	.719890	.548805	.1359	2.72	.2638E+05	.7599E+03	0.	0.0000000											
49	49	0	.7085E-02	.059315	-.255848	.306846	.0970	.67	.6471E+04	.5102E+02	0.	0.0000000											
50	50	0	.8553E-02	.175792	-.259676	.319721	.0970	.72	.6942E+04	.5938E+02	0.	0.0000000											
51	51	0	.1903E-01	.284434	-.106847	.346519	.0970	.85	.8241E+04	.6267E+02	0.	0.0000000											
52	52	0	.1261E-01	.375075	-.069570	.389913	.0970	1.12	.1008E+05	.1373E+03	0.	0.0000000											
53	53	0	.1670E-01	.429434	.092887	.447752	.0970	1.57	.1519E+05	.2536E+03	0.	0.0000000											
54	54	0	.2248E-01	.419526	.289296	.519530	.0970	2.15	.2086E+05	.4698E+03	0.	0.0000000											
55	55	0	.2915E-01	.316625	.405504	.594944	.0970	2.74	.2642E+05	.7768E+03	0.	0.0000000											
56	56	0	.3404E-01	.119416	.613936	.637699	.0970	3.13	.3037E+05	.1034E+04	0.	0.0000000											
57	57	0	.9869E-02	.060407	-.348273	.353880	.0581	.64	.6176E+04	.5619E+02	0.	0.0000000											
58	58	0	.9869E-02	.202737	-.299479	.368728	.0581	.70	.6831E+04	.6741E+02	0.	0.0000000											
59	59	0	.1150E-01	.328033	-.215565	.399634	.0581	.80	.8517E+04	.9858E+02	0.	0.0000000											
60	60	0	.1455E-01	.432567	-.098234	.448526	.0581	1.22	.1185E+05	.1725E+03	0.	0.0000000											
61	61	0	.1926E-01	.495258	.106202	.516383	.0581	1.79	.1735E+05	.3343E+03	0.	0.0000000											
62	62	0	.2594E-01	.483831	.333639	.599164	.0581	2.56	.2487E+05	.6451E+03	0.	0.0000000											
63	63	0	.3364E-01	.365157	.559922	.681524	.0581	3.38	.3276E+05	.1102E+04	0.	0.0000000											
64	64	0	.3928E-01	.137720	.708841	.735435	.0581	3.92	.3891E+05	.1493E+04	0.	0.0000000											
65	65	6	.1031E-01	.077502	.809516	.409932	.0191	.40	.3836E+04	.3955E+02	0.	0.0000000											
66	66	0	.1118E-01	.229694	-.339298	.417754	.0191	.42	.4088E+04	.4572E+02	0.	0.0000000											
67	67	0	.1312E-01	.371649	-.243894	.452770	.0191	.51	.4948E+04	.6491E+02	0.	0.0000000											
68	68	0	.1649E-01	.490082	-.090992	.508163	.0191	.75	.7312E+04	.1206E+03	0.	0.0000000											
69	69	0	.2183E-01	.561109	.128323	.585643	.0191	1.32	.1200E+05	.2794E+03	0.	0.0000000											
70	70	0	.2940E-01	.548162	.378001	.678830	.0191	2.37	.2295E+05	.6747E+03	0.	0.0000000											
71	71	0	.3813E-01	.413709	.634371	.772141	.0191	3.79	.3676E+05	.1402E+04	0.	0.0000000											
72	72	0	.4452E-01	.156831	.802183	.933220	.0191	4.93	.4781E+05	.2128E+04	0.	0.0000000											

[illegible]

EXAMPLE 3

*****PROGRAM OPTIONS*****
 VARIABLE BODY ORIENTATION
 POINT PRINT
 SYMMETRIC CONFIGURATION

*****DOUBLE PARAMETERS*****

DIAMETER 1.0000 FT
 ENTRY VELOCITY 50.000(FT/SEC)
 BODY ORIENTATION ANGLE 90.00 DEGREES
 INITIAL DEPTH 0.00000 FT TERMINATION STEP IS
 INITIAL PRESSURE CORRECTION FACTOR = .6760
 CENTROIDE COORDINATES 0.00000 0.00000 0.00000

NO	VX	VY	VZ	WX	CWT	M
1	0.0000	0.0000	-0.0000	0.0	1.262400	.050001
2	0.0000	0.0000	-0.0000	0.0	1.252000	.050000
3	0.0000	0.0000	-0.0000	0.0	1.232400	.050000
4	0.0000	0.0000	-0.0000	0.0	1.224200	.050000
5	0.0000	0.0000	-0.0000	0.0	1.207500	.050000
6	0.0000	0.0000	-0.0000	0.0	1.199200	.050000
7	0.0000	0.0000	-0.0000	0.0	1.183000	.050000
8	0.0000	0.0000	-0.0000	0.0	1.176100	.050000
9	0.0000	0.0000	-0.0000	0.0	1.160700	.050000
10	0.0000	0.0000	-0.0000	0.0	1.153000	.050000
11	0.0000	0.0000	-0.0000	0.0	1.137700	.050000
12	0.0000	0.0000	-0.0000	0.0	1.130000	.050000
13	0.0000	0.0000	-0.0000	0.0	1.114100	.050000
14	0.0000	0.0000	-0.0000	0.0	1.106000	.050000
15	0.0000	0.0000	-0.0000	0.0	1.089500	.050000
16	0.0000	0.0000	-0.0000	0.0	1.081100	.050000
17	0.0000	0.0000	-0.0000	0.0	1.067100	.050000
18	0.0000	0.0000	-0.0000	0.0	1.061500	.050000

*****GMD OPTIONS*****
 STANDARD

GMD SIZE	Z	NUMBER	K
0.00000	0.00000	0	0
-112400	-100000	1	0
-203500	-200000	2	0
-270500	-300000	3	0
-340400	-400000	4	0
-391300	-500000	5	0
-432300	-600000	6	0
-464500	-700000	7	0
-484500	-800000	8	0
-500000	-870000	9	0

NOTE
 1
 2
 3
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 11
 12

X	Y	Z	XP	YP	ZP
0.0000	-0.0001	0.0000	0.0000	-0.0001	-0.0000
-0.0001	-0.0000	0.0000	-0.0001	-0.0000	-0.0000
-0.0001	-0.0001	0.0000	-0.0001	-0.0001	-0.0000
-0.0000	-0.0001	0.0000	-0.0000	-0.0001	-0.0000
0.0000	-0.0001	0.0000	0.0000	-0.0001	-0.0000
-0.0000	-0.0001	0.0000	0.0000	-0.0001	-0.0000
-0.0001	-0.0001	0.0000	0.0000	-0.0001	-0.0000
-0.0001	-0.0000	0.0000	0.0000	-0.0001	-0.0000
-0.0001	-0.0000	0.0000	0.0000	-0.0001	-0.0000
-0.0001	-0.0000	0.0000	0.0000	-0.0001	-0.0000
-0.0001	-0.0001	0.0000	0.0000	-0.0001	-0.0000

13	-0.000	-0.001	0.0000	-0.000	-0.001	-0.000
14	0.0000	-1.124	1.000	0.0000	-1.124	-1.000
15	0.30	-1.039	1.000	0.430	-1.038	-1.000
16	-0.095	-0.795	1.000	-0.795	-0.795	-1.000
17	-1.038	-0.630	1.000	-1.034	-0.600	-1.000
18	-1.124	-0.000	1.000	-1.124	-0.000	-1.000
19	-1.038	-0.430	1.000	-1.034	-0.430	-1.000
20	-0.795	-0.795	1.000	-0.795	-0.795	-1.000
21	-0.430	-1.039	1.000	-0.430	-1.036	-1.000
22	-0.000	-1.124	1.000	-0.000	-1.124	-1.000
23	0.0000	-2.035	2.000	0.0000	-2.035	-2.000
24	-0.779	-1.880	2.000	-0.779	-1.880	-2.000
25	-1.439	-1.439	2.000	-1.439	-1.439	-2.000
26	-1.880	-0.779	2.000	-1.880	-0.779	-2.000
27	-2.035	-0.000	2.000	-2.035	-0.000	-2.000
28	-1.880	-0.779	2.000	-1.880	-0.779	-2.000
29	-1.439	-1.439	2.000	-1.439	-1.439	-2.000
30	-0.779	-1.880	2.000	-0.779	-1.880	-2.000
31	-0.000	-2.035	2.000	-0.000	-2.035	-2.000
32	0.0000	-2.785	3.000	0.0000	-2.785	-3.000
33	-1.046	-2.573	3.000	-1.066	-2.573	-3.000
34	-1.969	-1.969	3.000	-1.969	-1.969	-3.000
35	-2.573	-1.046	3.000	-2.573	-1.066	-3.000
36	-2.785	-0.000	3.000	-2.785	-0.000	-3.000
37	-2.573	-1.046	3.000	-2.573	-1.066	-3.000
38	-1.969	-1.969	3.000	-1.969	-1.969	-3.000
39	-1.046	-2.573	3.000	-1.066	-2.573	-3.000
40	-0.000	-2.785	3.000	-0.000	-2.785	-3.000
41	0.0000	-3.404	4.000	0.0000	-3.404	-4.000
42	-1.303	-3.145	4.000	-1.303	-3.145	-4.000
43	-2.407	-2.407	4.000	-2.407	-2.407	-4.000
44	-3.145	-1.303	4.000	-3.145	-1.303	-4.000
45	-3.404	-0.000	4.000	-3.404	-0.000	-4.000
46	-3.145	-1.303	4.000	-3.145	-1.303	-4.000
47	-2.407	-2.407	4.000	-2.407	-2.407	-4.000
48	-1.303	-3.145	4.000	-1.303	-3.145	-4.000
49	-0.000	-3.404	4.000	-0.000	-3.404	-4.000
50	0.0000	-3.145	5.000	0.0000	-3.145	-5.000
51	-1.437	-3.615	5.000	-1.437	-3.615	-5.000
52	-2.767	-2.767	5.000	-2.767	-2.767	-5.000
53	-3.615	-1.437	5.000	-3.615	-1.437	-5.000
54	-3.913	-0.000	5.000	-3.913	-0.000	-5.000
55	-3.615	-1.437	5.000	-3.615	-1.437	-5.000
56	-2.767	-2.767	5.000	-2.767	-2.767	-5.000
57	-1.437	-3.615	5.000	-1.437	-3.615	-5.000
58	-0.000	-3.913	5.000	-0.000	-3.913	-5.000
59	0.0000	-4.323	6.000	0.0000	-4.323	-6.000
60	-1.654	-3.994	6.000	-1.654	-3.994	-6.000
61	-3.057	-3.057	6.000	-3.057	-3.057	-6.000
62	-3.994	-1.654	6.000	-3.994	-1.654	-6.000
63	-4.323	-0.000	6.000	-4.323	-0.000	-6.000
64	-3.994	-1.654	6.000	-3.994	-1.654	-6.000
65	-3.057	-3.057	6.000	-3.057	-3.057	-6.000
66	-1.654	-3.994	6.000	-1.654	-3.994	-6.000
67	-0.000	-4.323	6.000	-0.000	-4.323	-6.000
68	0.0000	-4.645	7.000	0.0000	-4.645	-7.000
69	-1.178	-4.291	7.000	-1.178	-4.291	-7.000
70	-3.285	-3.285	7.000	-3.285	-3.285	-7.000
71	-4.291	-1.178	7.000	-4.291	-1.178	-7.000
72	-4.645	-0.000	7.000	-4.645	-0.000	-7.000
73	-4.291	-1.178	7.000	-4.291	-1.178	-7.000
74	-3.285	-3.285	7.000	-3.285	-3.285	-7.000
75	-1.178	-4.291	7.000	-1.178	-4.291	-7.000
76	-0.000	-4.645	7.000	-0.000	-4.645	-7.000
77	0.0000	-4.885	8.000	0.0000	-4.885	-8.000
78	-1.420	-4.513	8.000	-1.420	-4.513	-8.000

ELEMENT	1	2	3	4	IC	YC	ZC	RC	TC	AREA
79	3454	-3454	-8000	-3454	-3454	-07206	-96664	-07349	168.750	-3265E-02
80	4513	-1869	-8000	4513	-1869	-06111	-06664	-07349	146.250	-3265E-02
81	4885	-0800	-8000	4885	-0800	-04083	-06664	-07349	123.750	-3265E-02
82	4513	-1869	-8000	4513	-1869	-01434	-06664	-07349	101.250	-3265E-02
83	3454	-3454	-8000	3454	-3454	-01434	-06664	-07349	78.750	-3265E-02
84	1869	4513	-8000	1869	4513	-04083	-06664	-07349	56.250	-3265E-02
85	-0800	4885	-8000	-0800	4885	-06111	-06664	-07349	33.750	-3265E-02
86	8000	-5000	-8700	8000	-5000	-07206	-96664	-07349	11.250	-3265E-02
87	1913	-4619	-8700	1913	-4619	-15615	-15481	-15921	168.750	-8265E-02
88	3536	-3536	-8700	3536	-3536	-13238	-15481	-15921	146.250	-8265E-02
89	4619	-1913	-8700	4619	-1913	-08045	-15481	-15921	123.750	-8265E-02
90	5000	-0800	-8700	5000	-0800	-03106	-15481	-15921	101.250	-8265E-02
91	4619	1913	-8700	4619	1913	-08045	-15481	-15921	78.750	-8265E-02
92	3536	3536	-8700	3536	3536	-13238	-15481	-15921	56.250	-8265E-02
93	1913	4619	-8700	1913	4619	-15615	-15481	-15921	33.750	-8265E-02
94	-0800	5000	-8700	-0800	5000	-07206	-96664	-07349	11.250	-8265E-02
						-23370	-25259	-23828	168.750	-1167E-01
						-19012	-25259	-23828	146.250	-1167E-01
						-13238	-25259	-23828	123.750	-1167E-01
						-04649	-25259	-23828	101.250	-1167E-01
						19012	-25259	-23828	78.750	-1167E-01
						13238	-25259	-23828	56.250	-1167E-01
						04649	-25259	-23828	33.750	-1167E-01
						23370	-25259	-23828	11.250	-1167E-01
						25259	-25259	-38452	168.750	-1413E-01
						29066	-35167	-38452	146.250	-1413E-01
						25320	-35167	-38452	123.750	-1413E-01
						16918	-35167	-38452	101.250	-1413E-01
						25328	-35167	-38452	78.750	-1413E-01
						05941	-35167	-38452	56.250	-1413E-01
						07012	-35167	-38452	33.750	-1413E-01
						29066	-35167	-38452	11.250	-1413E-01
						35249	-45116	-35940	168.750	-1595E-01
						29083	-45116	-35940	146.250	-1595E-01
						19967	-45116	-35940	123.750	-1595E-01
						35249	-45116	-35940	101.250	-1595E-01
						07012	-45116	-35940	78.750	-1595E-01
						29083	-45116	-35940	56.250	-1595E-01
						35249	-45116	-35940	33.750	-1595E-01
						07012	-45116	-35940	11.250	-1595E-01
						29066	-55083	-48422	168.750	-1732E-01
						33610	-55083	-48422	146.250	-1732E-01
						22457	-55083	-48422	123.750	-1732E-01
						07806	-55083	-48422	101.250	-1732E-01
						39445	-55083	-48422	78.750	-1732E-01
						33610	-55083	-48422	56.250	-1732E-01
						22457	-55083	-48422	33.750	-1732E-01

48	66	67	58	57	19645	55083	48422	11250	1732E-01
49	64	69	66	59	88543	65868	43997	164750	1835E-01
50	69	70	61	60	24444	65868	43997	146250	1835E-01
51	70	71	62	61	36582	65868	43997	123750	1835E-01
52	71	72	63	62	43152	65060	43997	101250	1835E-01
53	72	73	64	63	68583	65060	43997	78750	1835E-01
54	73	74	65	64	34582	65060	43997	56250	1835E-01
55	74	75	66	65	24444	65060	43997	31750	1835E-01
56	75	76	67	66	98543	63152	45008	11250	1835E-01
57	77	75	69	68	69119	75842	46744	164750	1910E-01
58	78	79	70	69	25076	75842	46744	146250	1910E-01
59	79	80	71	70	30466	75842	46744	123750	1910E-01
60	80	81	72	71	45046	75842	46744	101250	1910E-01
61	81	82	73	72	69119	75842	46744	78750	1910E-01
62	82	83	74	73	30466	75842	46744	56250	1910E-01
63	83	84	75	74	25076	75842	46744	33750	1910E-01
64	84	85	76	75	69119	75842	46744	11250	1910E-01
65	85	87	78	76	89457	83514	48477	164750	1967E-01
66	86	88	79	77	26933	83514	48477	146250	1967E-01
67	87	89	80	78	40308	83514	48477	123750	1967E-01
68	88	90	81	80	47546	83514	48477	101250	1967E-01
69	89	91	82	81	69457	83514	48477	78750	1967E-01
70	90	92	83	82	40308	83514	48477	56250	1967E-01
71	92	93	84	83	26933	83514	48477	33750	1967E-01
72	93	94	85	84	69457	83514	48477	11250	1967E-01

```

STEP      1  DEPTH = 056C810  TIME = 0007923  DIMENSIONLESS TIME 0.8396142  WETTING FACTORS = 1.2622000 1.2520000
          SURFACE VFL ACTIVITY 0.002  0.000  0.000  0.000  WE  4.0000000000000000  Q0.000

```


FX = 0. 0.000000 CD = -3658917E+03 FM = -3924014E-07 CM = -1021196
 CZ = 0.000000 SMZ = 0. 0.000000 MY = -0.000000
 STEP 5 DEPTH = 250000 TIME = 0.000071 DIRECTIONLESS TIME 2023559 WETTING FACTORS = 1.2075000 1.1995000
 AVERAGE VELOCITY 0.000 0.000 MX = -0.000000

NO.	RFF.NO.	AREA	Y	Y	Z	TO	CP	P	FORCE
1	1	3265E-02	-014338	-072081	-066437	1493	1.10	2669E+04	8715E+01
2	2	3265E-02	-040831	-041104	-066437	1493	1.10	2669E+04	8715E+01
3	3	3265E-02	-061104	-040831	-066437	1493	1.10	2669E+04	8715E+01
4	4	3265E-02	-072081	-041338	-066437	1493	1.10	2669E+04	8715E+01
5	5	3265E-02	-083104	-040831	-066437	1493	1.10	2669E+04	8715E+01
6	6	3265E-02	-094081	-041338	-066437	1493	1.10	2669E+04	8715E+01
7	7	3265E-02	-105104	-040831	-066437	1493	1.10	2669E+04	8715E+01
8	8	3265E-02	-116104	-041338	-066437	1493	1.10	2669E+04	8715E+01
9	9	3265E-02	-127081	-040831	-066437	1493	1.10	2669E+04	8715E+01
10	10	3265E-02	-138104	-041338	-066437	1493	1.10	2669E+04	8715E+01
11	11	3265E-02	-149081	-040831	-066437	1493	1.10	2669E+04	8715E+01
12	12	3265E-02	-160104	-041338	-066437	1493	1.10	2669E+04	8715E+01
13	13	3265E-02	-171081	-040831	-066437	1493	1.10	2669E+04	8715E+01
14	14	3265E-02	-182104	-041338	-066437	1493	1.10	2669E+04	8715E+01
15	15	3265E-02	-193081	-040831	-066437	1493	1.10	2669E+04	8715E+01
16	16	3265E-02	-204104	-041338	-066437	1493	1.10	2669E+04	8715E+01

STEP 5 DEPTH = 250000 TIME = 0.000071 DIRECTIONLESS TIME 2023559 WETTING FACTORS = 1.2075000 1.1995000
 AVERAGE VELOCITY 0.000 0.000 MX = -0.000000

FX = 0. 0.000000 CD = -4826207E+03 FM = -1655361E-07 CM = -2114040
 CZ = 0.000000 SMZ = 0. 0.000000 MY = -0.000000
 STEP 5 DEPTH = 300000 TIME = 0.000071 DIRECTIONLESS TIME 2440400 WETTING FACTORS = 1.1995000 1.1630000
 AVERAGE VELOCITY 0.000 0.000 MX = -0.000000

NO.	RFF.NO.	AREA	Y	Y	Z	TO	CP	P	FORCE
1	1	3265E-02	-014338	-072081	-066437	1493	1.07	2607E+04	8510E+01
2	2	3265E-02	-040831	-041104	-066437	1493	1.07	2607E+04	8510E+01
3	3	3265E-02	-061104	-040831	-066437	1493	1.07	2607E+04	8510E+01
4	4	3265E-02	-072081	-041338	-066437	1493	1.07	2607E+04	8510E+01
5	5	3265E-02	-083104	-040831	-066437	1493	1.07	2607E+04	8510E+01
6	6	3265E-02	-094081	-041338	-066437	1493	1.07	2607E+04	8510E+01
7	7	3265E-02	-105104	-040831	-066437	1493	1.07	2607E+04	8510E+01
8	8	3265E-02	-116104	-041338	-066437	1493	1.07	2607E+04	8510E+01
9	9	3265E-02	-127081	-040831	-066437	1493	1.07	2607E+04	8510E+01
10	10	3265E-02	-138104	-041338	-066437	1493	1.07	2607E+04	8510E+01
11	11	3265E-02	-149081	-040831	-066437	1493	1.07	2607E+04	8510E+01
12	12	3265E-02	-160104	-041338	-066437	1493	1.07	2607E+04	8510E+01
13	13	3265E-02	-171081	-040831	-066437	1493	1.07	2607E+04	8510E+01
14	14	3265E-02	-182104	-041338	-066437	1493	1.07	2607E+04	8510E+01
15	15	3265E-02	-193081	-040831	-066437	1493	1.07	2607E+04	8510E+01
16	16	3265E-02	-204104	-041338	-066437	1493	1.07	2607E+04	8510E+01

STEP 5 DEPTH = 300000 TIME = 0.000071 DIRECTIONLESS TIME 2440400 WETTING FACTORS = 1.1995000 1.1630000
 AVERAGE VELOCITY 0.000 0.000 MX = -0.000000

FX = 0. 0.000000 CD = -4826207E+03 FM = -1655361E-07 CM = -2114040
 CZ = 0.000000 SMZ = 0. 0.000000 MY = -0.000000
 STEP 5 DEPTH = 300000 TIME = 0.000071 DIRECTIONLESS TIME 2440400 WETTING FACTORS = 1.1995000 1.1630000
 AVERAGE VELOCITY 0.000 0.000 MX = -0.000000

NO.	RFF.NO.	AREA	Y	Y	Z	TO	CP	P	FORCE
1	1	3265E-02	-014338	-072081	-066437	1493	1.07	2607E+04	8510E+01
2	2	3265E-02	-040831	-041104	-066437	1493	1.07	2607E+04	8510E+01
3	3	3265E-02	-061104	-040831	-066437	1493	1.07	2607E+04	8510E+01
4	4	3265E-02	-072081	-041338	-066437	1493	1.07	2607E+04	8510E+01
5	5	3265E-02	-083104	-040831	-066437	1493	1.07	2607E+04	8510E+01
6	6	3265E-02	-094081	-041338	-066437	1493	1.07	2607E+04	8510E+01
7	7	3265E-02	-105104	-040831	-066437	1493	1.07	2607E+04	8510E+01
8	8	3265E-02	-116104	-041338	-066437	1493	1.07	2607E+04	8510E+01
9	9	3265E-02	-127081	-040831	-066437	1493	1.07	2607E+04	8510E+01
10	10	3265E-02	-138104	-041338	-066437	1493	1.07	2607E+04	8510E+01
11	11	3265E-02	-149081	-040831	-066437	1493	1.07	2607E+04	8510E+01
12	12	3265E-02	-160104	-041338	-066437	1493	1.07	2607E+04	8510E+01
13	13	3265E-02	-171081	-040831	-066437	1493	1.07	2607E+04	8510E+01
14	14	3265E-02	-182104	-041338	-066437	1493	1.07	2607E+04	8510E+01
15	15	3265E-02	-193081	-040831	-066437	1493	1.07	2607E+04	8510E+01
16	16	3265E-02	-204104	-041338	-066437	1493	1.07	2607E+04	8510E+01

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NO.	REF. NO.	400	AREA	T	Y	Z	T ₀	CP	P	FORCE
1	1	0	3265E-02	014338	-072001	066637	2758	1.00	2428E+04	7928E+01
2	2	0	3265E-02	040831	-041108	066637	2758	1.00	2428E+04	7928E+01
3	3	0	3265E-02	061108	-045831	066637	2758	1.00	2428E+04	7928E+01
4	4	0	3265E-02	072001	-014338	066637	2758	1.00	2428E+04	7928E+01
5	5	0	3265E-02	072001	014338	066637	2758	1.00	2428E+04	7928E+01
6	6	0	3265E-02	061108	040831	066637	2758	1.00	2428E+04	7928E+01
7	7	0	3265E-02	040831	040831	066637	2758	1.00	2428E+04	7928E+01
8	8	0	3265E-02	014338	072001	066637	2758	1.00	2428E+04	7928E+01
9	9	9	8265E-02	031068	-156158	066637	2758	1.00	2428E+04	7928E+01
10	10	0	8265E-02	084452	-132378	154806	2046	79	1904E+04	1573E+02
11	11	0	8265E-02	132378	-094452	154806	2046	79	1904E+04	1573E+02
12	12	0	8265E-02	014338	-031068	154806	2046	79	1904E+04	1573E+02
13	13	0	8265E-02	156158	031068	154806	2046	79	1904E+04	1573E+02
14	14	0	8265E-02	132378	084452	154806	2046	79	1904E+04	1573E+02
15	15	0	8265E-02	084452	132378	154806	2046	79	1904E+04	1573E+02
16	16	0	8265E-02	031068	156158	154806	2046	79	1904E+04	1573E+02
17	17	0	1167E-01	046406	-233698	252593	1241	61	1488E+04	1737E+02
18	18	0	1167E-01	046406	-233698	252593	1241	61	1488E+04	1737E+02
19	19	0	1167E-01	198120	-132380	252593	1241	61	1488E+04	1737E+02
20	20	0	1167E-01	233698	-046406	252593	1241	61	1488E+04	1737E+02
21	21	0	1167E-01	233698	046406	252593	1241	61	1488E+04	1737E+02
22	22	0	1167E-01	198120	132380	252593	1241	61	1488E+04	1737E+02
23	23	0	1167E-01	132380	198120	252593	1241	61	1488E+04	1737E+02
24	24	0	1167E-01	046406	233698	252593	1241	61	1488E+04	1737E+02
25	25	0	1413E-01	059408	-298665	351667	0410	35	8571E+03	1211E+02
26	26	0	1413E-01	169180	-253196	351667	0410	35	8571E+03	1211E+02
27	27	0	1413E-01	298665	253196	351667	0410	35	8571E+03	1211E+02
28	28	0	1413E-01	298665	253196	351667	0410	35	8571E+03	1211E+02
29	29	0	1413E-01	169180	-253196	351667	0410	35	8571E+03	1211E+02
30	30	0	1413E-01	298665	253196	351667	0410	35	8571E+03	1211E+02
31	31	0	1413E-01	169180	-253196	351667	0410	35	8571E+03	1211E+02
32	32	0	1413E-01	298665	253196	351667	0410	35	8571E+03	1211E+02

FX = 0.00000000
FY = 0.00000000

SMZ = 0.00000000
MZ = 0.00000000

SNZ = 0.00000000
MNZ = 0.00000000

FM = 0.00000000
FN = 0.00000000

CD = 0.00000000
CN = 0.00000000

STEP 0 DEPTH = 4500010 TIME = 0.000 DIMENSIONLESS TIME 3718677 WETTING FACTORS = 1.1687888 1.1530000
AVERAGE VELOCITY 0.000

NO.	REF. NO.	400	AREA	X	Y	Z	T ₀	CP	P	FORCE
1	1	0	3265E-02	014338	-072001	066637	3180	97	2347E+04	7662E+01
2	2	0	3265E-02	040831	-041108	066637	3180	97	2347E+04	7662E+01
3	3	0	3265E-02	061108	-040831	066637	3180	97	2347E+04	7662E+01
4	4	0	3265E-02	072001	-014338	066637	3180	97	2347E+04	7662E+01
5	5	0	3265E-02	072001	014338	066637	3180	97	2347E+04	7662E+01
6	6	0	3265E-02	061108	040831	066637	3180	97	2347E+04	7662E+01
7	7	0	3265E-02	040831	040831	066637	3180	97	2347E+04	7662E+01
8	8	0	3265E-02	014338	072001	066637	3180	97	2347E+04	7662E+01
9	9	0	8265E-02	031068	-156158	066637	2477	75	1810E+04	1496E+02
10	10	0	8265E-02	084452	-132378	154806	2477	75	1810E+04	1496E+02
11	11	0	8265E-02	132378	-094452	154806	2477	75	1810E+04	1496E+02
12	12	0	8265E-02	014338	-031068	154806	2477	75	1810E+04	1496E+02
13	13	0	8265E-02	156158	031068	154806	2477	75	1810E+04	1496E+02
14	14	0	8265E-02	132378	084452	154806	2477	75	1810E+04	1496E+02
15	15	0	8265E-02	084452	132378	154806	2477	75	1810E+04	1496E+02
16	16	0	8265E-02	031068	156158	154806	2477	75	1810E+04	1496E+02
17	17	0	1167E-01	046406	-233698	252593	1672	55	1329E+04	1551E+02
18	18	0	1167E-01	046406	-233698	252593	1672	55	1329E+04	1551E+02
19	19	0	1167E-01	198120	-132380	252593	1672	55	1329E+04	1551E+02
20	20	0	1167E-01	233698	-046406	252593	1672	55	1329E+04	1551E+02
21	21	0	1167E-01	233698	046406	252593	1672	55	1329E+04	1551E+02
22	22	0	1167E-01	198120	132380	252593	1672	55	1329E+04	1551E+02

FX = 9. FD = .5331906E+03 FN = -.007372E-07 SMX = -.00000000 MY = 0. SMZ = 0. 0.00000000
 CX = 0.00000000 CD = .2799593 CN = -.00000000
 STEP 10 DEPTH = .5000010 TIME = .0003047 DIMENSIONLESS TIME .4152328 NETTING FACTORS = 1.1530000 1.1377000
 AVERAGE VELOCITY 0.000

NO.	REF. NO.	MOO	AREA	X	Y	Z	T ₀	CP	P	FORCE
23	23	0	.1167E-01	.132380	.190120	.252503	.1572	.55	.1329E+04	.1551E+02
24	24	0	.1167E-01	.046406	.252503	.1672	.55	.55	.1329E+04	.1551E+02
25	25	0	.1413E-01	.059408	.299665	.351667	.0800	.39	.9403E+03	.1328E+02
26	26	0	.1413E-01	.169140	.253196	.351667	.0800	.39	.9403E+03	.1328E+02
27	27	0	.1413E-01	.253196	.149180	.351667	.0800	.39	.9403E+03	.1328E+02
28	28	0	.1413E-01	.298665	.059408	.351667	.0800	.39	.9403E+03	.1328E+02
29	29	0	.1413E-01	.298665	.059408	.351667	.0800	.39	.9403E+03	.1328E+02
30	30	0	.1413E-01	.253196	.169140	.351667	.0800	.39	.9403E+03	.1328E+02
31	31	0	.1413E-01	.169140	.253196	.351667	.0800	.39	.9403E+03	.1328E+02
32	32	0	.1413E-01	.059408	.298665	.351667	.0800	.39	.9403E+03	.1328E+02
33	33	1	.7708E-02	.067597	.339832	.425301	.0213	.19	.4659E+03	.3587E+01
34	34	1	.7708E-02	.192580	.248096	.425301	.0213	.19	.4659E+03	.3587E+01
35	35	1	.7708E-02	.278896	.142500	.425301	.0213	.19	.4659E+03	.3587E+01
36	36	1	.7708E-02	.339832	.067597	.425301	.0213	.19	.4659E+03	.3587E+01
37	37	1	.7708E-02	.339832	.067597	.425301	.0213	.19	.4659E+03	.3587E+01
38	38	1	.7708E-02	.278896	.142500	.425301	.0213	.19	.4659E+03	.3587E+01
39	39	1	.7708E-02	.192580	.248096	.425301	.0213	.19	.4659E+03	.3587E+01
40	40	1	.7708E-02	.067597	.339832	.425301	.0213	.19	.4659E+03	.3587E+01

STEP 10 DEPTH = .5000010 TIME = .0003047 DIMENSIONLESS TIME .4152328 NETTING FACTORS = 1.1530000 1.1377000
 AVERAGE VELOCITY 0.000

NO.	REF. NO.	MOO	AREA	X	Y	Z	T ₀	CP	P	FORCE
1	1	0	.3265E-02	.014338	.072081	.066437	.3622	.94	.2288E+04	.7472E+01
2	2	0	.3265E-02	.040331	.071100	.066437	.3622	.94	.2288E+04	.7472E+01
3	3	0	.3265E-02	.061100	.040331	.066437	.3622	.94	.2288E+04	.7472E+01
4	4	0	.3265E-02	.072081	.014338	.066437	.3622	.94	.2288E+04	.7472E+01
5	5	0	.3265E-02	.072081	.014338	.066437	.3622	.94	.2288E+04	.7472E+01
6	6	0	.3265E-02	.061100	.040331	.066437	.3622	.94	.2288E+04	.7472E+01
7	7	0	.3265E-02	.040331	.071100	.066437	.3622	.94	.2288E+04	.7472E+01
8	8	0	.3265E-02	.014338	.072081	.066437	.3622	.94	.2288E+04	.7472E+01
9	9	0	.8265E-02	.031060	.156150	.154406	.2911	.72	.1753E+04	.1449E+02
10	10	0	.8265E-02	.088452	.132378	.154406	.2911	.72	.1753E+04	.1449E+02
11	11	0	.8265E-02	.132378	.088452	.154406	.2911	.72	.1753E+04	.1449E+02
12	12	0	.8265E-02	.156150	.031060	.154406	.2911	.72	.1753E+04	.1449E+02
13	13	0	.8265E-02	.156150	.031060	.154406	.2911	.72	.1753E+04	.1449E+02
14	14	0	.8265E-02	.132378	.088452	.154406	.2911	.72	.1753E+04	.1449E+02
15	15	0	.8265E-02	.088452	.132378	.154406	.2911	.72	.1753E+04	.1449E+02
16	16	0	.8265E-02	.031060	.156150	.154406	.2911	.72	.1753E+04	.1449E+02
17	17	0	.1167E-01	.046406	.253196	.252503	.2106	.52	.1271E+04	.1484E+02
18	18	0	.1167E-01	.132380	.190120	.252503	.2106	.52	.1271E+04	.1484E+02
19	19	0	.1167E-01	.190120	.132380	.252503	.2106	.52	.1271E+04	.1484E+02
20	20	0	.1167E-01	.253196	.046406	.252503	.2106	.52	.1271E+04	.1484E+02
21	21	0	.1167E-01	.253196	.046406	.252503	.2106	.52	.1271E+04	.1484E+02
22	22	0	.1167E-01	.190120	.132380	.252503	.2106	.52	.1271E+04	.1484E+02
23	23	0	.1167E-01	.132380	.190120	.252503	.2106	.52	.1271E+04	.1484E+02
24	24	0	.1167E-01	.046406	.253196	.252503	.2106	.52	.1271E+04	.1484E+02
25	25	0	.1413E-01	.059408	.299665	.351667	.1274	.37	.8988E+03	.1258E+02
26	26	0	.1413E-01	.169140	.253196	.351667	.1274	.37	.8988E+03	.1258E+02
27	27	0	.1413E-01	.253196	.169140	.351667	.1274	.37	.8988E+03	.1258E+02
28	28	0	.1413E-01	.299665	.059408	.351667	.1274	.37	.8988E+03	.1258E+02
29	29	0	.1413E-01	.299665	.059408	.351667	.1274	.37	.8988E+03	.1258E+02
30	30	0	.1413E-01	.253196	.169140	.351667	.1274	.37	.8988E+03	.1258E+02
31	31	0	.1413E-01	.169140	.253196	.351667	.1274	.37	.8988E+03	.1258E+02
32	32	0	.1413E-01	.059408	.299665	.351667	.1274	.37	.8988E+03	.1258E+02
33	33	0	.1594E-01	.070115	.352493	.451159	.0422	.10	.2439E+03	.3891E+01
34	34	0	.1594E-01	.190471	.248096	.451159	.0422	.10	.2439E+03	.3891E+01
35	35	0	.1594E-01	.296829	.067597	.451159	.0422	.10	.2439E+03	.3891E+01
36	36	0	.1594E-01	.352493	.070115	.451159	.0422	.10	.2439E+03	.3891E+01
37	37	0	.1594E-01	.352493	.070115	.451159	.0422	.10	.2439E+03	.3891E+01
38	38	0	.1594E-01	.296829	.067597	.451159	.0422	.10	.2439E+03	.3891E+01

[illegible]

STEP	12	DEPTH =	0.000010	TIME =	0.000	DIAMENSIONLESS TIME	0.000	WEIGHTING FACTORS =	1.1300000	1.1141000
AVERAGE VELOCITY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NO.	OFF. NO.	MOD	AREA	X	Y	Z	T*	CP	P	FORCE
1	0	0	3245E-02	01433A	-0.0720E1	0.06637	4504	90	2174E+04	7099E+01
2	1	0	3245E-02	040431	-0.01100	0.06637	4504	90	2174E+04	7099E+01
3	2	0	3245E-02	06110A	-0.00431	0.06637	4504	90	2174E+04	7099E+01
4	3	0	3245E-02	0720A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
5	4	0	3245E-02	0820A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
6	5	0	3245E-02	0920A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
7	6	0	3245E-02	1020A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
8	7	0	3245E-02	1120A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
9	8	0	3245E-02	1220A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
10	9	0	3245E-02	1320A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
11	10	0	3245E-02	1420A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
12	11	0	3245E-02	1520A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
13	12	0	3245E-02	1620A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
14	13	0	3245E-02	1720A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
15	14	0	3245E-02	1820A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
16	15	0	3245E-02	1920A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
17	16	0	3245E-02	2020A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
18	17	0	3245E-02	2120A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
19	18	0	3245E-02	2220A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
20	19	0	3245E-02	2320A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
21	20	0	3245E-02	2420A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
22	21	0	3245E-02	2520A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
23	22	0	3245E-02	2620A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
24	23	0	3245E-02	2720A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
25	24	0	3245E-02	2820A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
26	25	0	3245E-02	2920A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
27	26	0	3245E-02	3020A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
28	27	0	3245E-02	3120A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
29	28	0	3245E-02	3220A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
30	29	0	3245E-02	3320A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
31	30	0	3245E-02	3420A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
32	31	0	3245E-02	3520A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
33	32	0	3245E-02	3620A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
34	33	0	3245E-02	3720A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
35	34	0	3245E-02	3820A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
36	35	0	3245E-02	3920A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
37	36	0	3245E-02	4020A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
38	37	0	3245E-02	4120A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
39	38	0	3245E-02	4220A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
40	39	0	3245E-02	4320A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
41	40	0	3245E-02	4420A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
42	41	0	3245E-02	4520A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
43	42	0	3245E-02	4620A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
44	43	0	3245E-02	4720A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
45	44	0	3245E-02	4820A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
46	45	0	3245E-02	4920A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
47	46	0	3245E-02	5020A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
48	47	0	3245E-02	5120A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01
49	48	0	3245E-02	5220A1	-0.01433A	0.06637	4504	90	2174E+04	7099E+01

CM = 0. 0.0000000 CD = 0.0000000 FM = -0.344-123E-07 SWR = -0.4272517E-07 SMZ = 0. 0.0000000 WZ = 0. 0.0000000

STEP	13	DEPTH =	0.000010	TIME =	0.000	DIAMENSIONLESS TIME	0.000	WEIGHTING FACTORS =	1.1141000	1.1060000
AVERAGE VELOCITY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NO.	OFF. NO.	MOD	AREA	X	Y	Z	T*	CP	P	FORCE
1	0	0	3245E-02	01433A	-0.0720A1	0.06637	4553	8A	2123E+04	6931E+01
2	1	0	3245E-02	040431	-0.01100	0.06637	4553	8A	2123E+04	6931E+01
3	2	0	3245E-02	06110A	-0.00431	0.06637	4553	8A	2123E+04	6931E+01
4	3	0	3245E-02	0720A1	-0.01433A	0.06637	4553	8A	2123E+04	6931E+01

NO.	REF. NO.	MOD	AREA	DEPTH = .7000010	TIME = .0118703	DIMENSIONLESS TIME	WETTING FACTORS =	1-1000000
			AVERAGE VELOCITY	0.000	-50.000	90.000		
5	5	0	3265E-02	.072081	.014338	.065637	.4953	.88
6	6	0	3265E-02	.061108	.040831	.065637	.4953	.88
7	7	0	3265E-02	.040931	.061108	.065637	.4953	.88
8	8	0	3265E-02	.014338	.072081	.065637	.4953	.88
9	9	0	3265E-02	.089452	.132378	.154406	.4241	.65
10	10	0	3265E-02	.089452	.132378	.154406	.4241	.65
11	11	0	3265E-02	.132378	.089452	.154406	.4241	.65
12	12	0	3265E-02	.154406	.132378	.154406	.4241	.65
13	13	0	3265E-02	.154406	.132378	.154406	.4241	.65
14	14	0	3265E-02	.132378	.154406	.154406	.4241	.65
15	15	0	3265E-02	.089452	.132378	.154406	.4241	.65
16	16	0	3265E-02	.089452	.132378	.154406	.4241	.65
17	17	0	3265E-02	.061108	.040831	.065637	.4953	.88
18	18	0	3265E-02	.040931	.061108	.065637	.4953	.88
19	19	0	3265E-02	.014338	.072081	.065637	.4953	.88
20	20	0	3265E-02	.089452	.132378	.154406	.4241	.65
21	21	0	3265E-02	.089452	.132378	.154406	.4241	.65
22	22	0	3265E-02	.132378	.089452	.154406	.4241	.65
23	23	0	3265E-02	.154406	.132378	.154406	.4241	.65
24	24	0	3265E-02	.154406	.132378	.154406	.4241	.65
25	25	0	3265E-02	.132378	.154406	.154406	.4241	.65
26	26	0	3265E-02	.089452	.132378	.154406	.4241	.65
27	27	0	3265E-02	.089452	.132378	.154406	.4241	.65
28	28	0	3265E-02	.061108	.040831	.065637	.4953	.88
29	29	0	3265E-02	.040931	.061108	.065637	.4953	.88
30	30	0	3265E-02	.014338	.072081	.065637	.4953	.88
31	31	0	3265E-02	.089452	.132378	.154406	.4241	.65
32	32	0	3265E-02	.089452	.132378	.154406	.4241	.65
33	33	0	3265E-02	.132378	.089452	.154406	.4241	.65
34	34	0	3265E-02	.154406	.132378	.154406	.4241	.65
35	35	0	3265E-02	.154406	.132378	.154406	.4241	.65
36	36	0	3265E-02	.132378	.154406	.154406	.4241	.65
37	37	0	3265E-02	.089452	.132378	.154406	.4241	.65
38	38	0	3265E-02	.089452	.132378	.154406	.4241	.65
39	39	0	3265E-02	.132378	.089452	.154406	.4241	.65
40	40	0	3265E-02	.154406	.132378	.154406	.4241	.65
41	41	0	3265E-02	.154406	.132378	.154406	.4241	.65
42	42	0	3265E-02	.132378	.154406	.154406	.4241	.65
43	43	0	3265E-02	.089452	.132378	.154406	.4241	.65
44	44	0	3265E-02	.089452	.132378	.154406	.4241	.65
45	45	0	3265E-02	.132378	.089452	.154406	.4241	.65
46	46	0	3265E-02	.154406	.132378	.154406	.4241	.65
47	47	0	3265E-02	.154406	.132378	.154406	.4241	.65
48	48	0	3265E-02	.132378	.154406	.154406	.4241	.65
49	49	1	9089E-02	.089452	.132378	.154406	.4241	.65
50	50	1	9089E-02	.089452	.132378	.154406	.4241	.65
51	51	1	9089E-02	.132378	.089452	.154406	.4241	.65
52	52	1	9089E-02	.154406	.132378	.154406	.4241	.65
53	53	1	9089E-02	.154406	.132378	.154406	.4241	.65
54	54	1	9089E-02	.132378	.154406	.154406	.4241	.65
55	55	1	9089E-02	.089452	.132378	.154406	.4241	.65
56	56	1	9089E-02	.089452	.132378	.154406	.4241	.65
X =	0.	0.0000000	CD = .6515229E+03	FN = -.9426827E-07	CMX = -.7683373E-07	SMY = 0.	SMZ = 0.	0.0000000
Y =			.2370421	CN = -.6000000	MY = -.0000000			0.0000000
STEP	1A	DEPTH = .7000010	TIME = .0118703	DIMENSIONLESS TIME	.595161	WETTING FACTORS =	1-1000000	
		AVERAGE VELOCITY	0.000	-50.000	90.000			
NO.	REF. NO.	MOD	AREA	X	Y	Z	T ₀	CP
1	1	0	3265E-02	.014338	-.072081	.065637	.5405	.86
2	2	0	3265E-02	.040931	-.066108	.065637	.5485	.86
3	3	0	3265E-02	.061108	-.040831	.065637	.5485	.86
4	4	0	3265E-02	.072081	-.014338	.065637	.5485	.86

FX = 0.	FD = 0.	FX = 0.	FD = 0.
FX = 0.00000000	CD = 0.00000000	FX = 0.00000000	CD = 0.00000000
FX = 0.2241417	CN = -0.00000000	FX = 0.2241417	CN = -0.00000000
FX = -0.4762023F-07	FM = -0.400727F-07	FX = -0.4762023F-07	FM = -0.400727F-07
FX = 0.00000000	MY = 0.00000000	FX = 0.00000000	MY = 0.00000000
FX = 0.00000000	NZ = 0.00000000	FX = 0.00000000	NZ = 0.00000000

```
STEP      15   DEPTH = -750010    TIME = -.0127492    DURATIONLESS TIME    .639408    WETTING FACTORS = 1.0095000 1.0811800  
AVERAGE VELOCITY    0.000    0.000    -50.000    BX    0.000    ORIENTATION    90.000
```

NO.	REF.NO.	MOI	APEA	X	Y	Z	T ₀	C _P	P	FORCE
1	1	0	.3245E-02	.614338	-.072081	.066437	.5864	.04	.2039E+04	.6656E+01
2	2	0	.3265E-02	.042431	-.061109	.066437	.5064	.04	.2039E+04	.6656E+01
3	3	0	.3265E-02	.061109	-.040-31	.066437	.5864	.04	.2039E+04	.6656E+01
4	4	0	.3245E-02	.072081	.066437	.066437	.5864	.04	.2039E+04	.6656E+01

5	5	3265E-02	.0720E1	.014330	.066437	.5864	.84	.2039E+04	.6656E+01
6	6	3265E-02	.06110A	.040931	.066437	.5864	.84	.2039E+04	.6656E+01
7	7	3265E-02	.040931	.041108	.066437	.5864	.84	.2039E+04	.6656E+01
8	8	3265E-02	.01433A	.0720E1	.066437	.5864	.84	.2039E+04	.6656E+01
9	9	8265E-02	.031060	.154106	.5152	.62	.62	.1500E+04	.1240E+02
10	10	8265E-02	.084652	.132376	.154106	.5152	.62	.1500E+04	.1240E+02
11	11	8265E-02	.13237A	.084652	.154106	.5152	.62	.1500E+04	.1240E+02
12	12	8265E-02	.154150	.031060	.154106	.5152	.62	.1500E+04	.1240E+02
13	13	8265E-02	.154150	.031060	.154106	.5152	.62	.1500E+04	.1240E+02
14	14	8265E-02	.13237A	.084652	.154106	.5152	.62	.1500E+04	.1240E+02
15	15	8265E-02	.084652	.13237A	.154106	.5152	.62	.1500E+04	.1240E+02
16	16	8265E-02	.031060	.154106	.5152	.62	.62	.1500E+04	.1240E+02
17	17	1147E-01	.044486	.273369	.252593	.434A	.41	.9924E+03	.1150E+02
18	18	1147E-01	.1323A0	.102120	.252593	.434A	.41	.9924E+03	.1150E+02
19	19	1147E-01	.198120	.132380	.252593	.434A	.41	.9924E+03	.1150E+02
20	20	1147E-01	.233438	.044486	.252593	.434A	.41	.9924E+03	.1150E+02
21	21	1147E-01	.23343A	.044486	.252593	.434A	.41	.9924E+03	.1150E+02
22	22	1147E-01	.198120	.132380	.252593	.434A	.41	.9924E+03	.1150E+02
23	23	1147E-01	.1323A0	.102120	.252593	.434A	.41	.9924E+03	.1150E+02
24	24	1147E-01	.044486	.273369	.252593	.434A	.41	.9924E+03	.1150E+02
25	25	1147E-01	.059408	.294665	.351667	.3516	.23	.5538E+03	.7822E+01
26	26	1147E-01	.169180	.253146	.351667	.3516	.23	.5538E+03	.7822E+01
27	27	1147E-01	.25314A	.169180	.351667	.3516	.23	.5538E+03	.7822E+01
28	28	1147E-01	.294665	.059408	.351667	.3516	.23	.5538E+03	.7822E+01
29	29	1147E-01	.253146	.169180	.351667	.3516	.23	.5538E+03	.7822E+01
30	30	1147E-01	.169180	.253146	.351667	.3516	.23	.5538E+03	.7822E+01
31	31	1147E-01	.059408	.294665	.351667	.3516	.23	.5538E+03	.7822E+01
32	32	1147E-01	.044486	.273369	.351667	.3516	.23	.5538E+03	.7822E+01
33	33	1595E-01	.070115	.352493	.451159	.2664	.08	.1922E+03	.3067E+01
34	34	1595E-01	.194671	.288829	.451159	.2664	.08	.1922E+03	.3067E+01
35	35	1595E-01	.298829	.194671	.451159	.2664	.08	.1922E+03	.3067E+01
36	36	1595E-01	.352493	.070115	.451159	.2664	.08	.1922E+03	.3067E+01
37	37	1595E-01	.070115	.352493	.451159	.2664	.08	.1922E+03	.3067E+01
38	38	1595E-01	.298829	.194671	.451159	.2664	.08	.1922E+03	.3067E+01
39	39	1595E-01	.194671	.288829	.451159	.2664	.08	.1922E+03	.3067E+01
40	40	1595E-01	.070115	.352493	.451159	.2664	.08	.1922E+03	.3067E+01
41	41	1732E-01	.078840	.306454	.550430	.1793	.00	.00	.00
42	42	1732E-01	.224573	.336097	.550430	.1793	.00	.00	.00
43	43	1732E-01	.336097	.224573	.550430	.1793	.00	.00	.00
44	44	1732E-01	.394454	.078840	.550430	.1793	.00	.00	.00
45	45	1732E-01	.078840	.394454	.550430	.1793	.00	.00	.00
46	46	1732E-01	.336097	.224573	.550430	.1793	.00	.00	.00
47	47	1732E-01	.224573	.336097	.550430	.1793	.00	.00	.00
48	48	1732E-01	.078840	.394454	.550430	.1793	.00	.00	.00
49	49	1732E-01	.394454	.078840	.550430	.1793	.00	.00	.00
50	50	1835E-01	.244436	.345682	.650598	.0904	.00	.00	.00
51	51	1835E-01	.345682	.244436	.650598	.0904	.00	.00	.00
52	52	1835E-01	.345682	.244436	.650598	.0904	.00	.00	.00
53	53	1835E-01	.431519	.085434	.650598	.0904	.00	.00	.00
54	54	1835E-01	.085434	.431519	.650598	.0904	.00	.00	.00
55	55	1835E-01	.244436	.345682	.650598	.0904	.00	.00	.00
56	56	1835E-01	.345682	.244436	.650598	.0904	.00	.00	.00
57	57	9430E-02	.090031	.452617	.725107	.0228	.00	.00	.00
58	58	9430E-02	.256387	.383710	.725107	.0228	.00	.00	.00
59	59	9430E-02	.383710	.256387	.725107	.0228	.00	.00	.00
60	60	9430E-02	.452617	.090031	.725107	.0228	.00	.00	.00
61	61	9430E-02	.452617	.090031	.725107	.0228	.00	.00	.00
62	62	9430E-02	.383710	.256387	.725107	.0228	.00	.00	.00
63	63	9430E-02	.256387	.383710	.725107	.0228	.00	.00	.00
64	64	9430E-02	.090031	.452617	.725107	.0228	.00	.00	.00

FX = 0. 8.000000 CD = .407734E+03 FN = -.521365E-07 SMX = -.462000E-07 SMY = 0. 8.000000 WZ = 0. 8.000000

STEP	16	DEPTH = .0000010	TIME = .0137132	DIMENSIONLESS TIME	WETTING FACTORS = 1.0011000	1.0671000				
AVERAGE VELOCITY	0.000	0.000	0.000	0.000	0.000	0.000				
REF. NO.	NO.	AREA	MOO	X	Y	Z	T*	CP	P	FORCE
1	1	3265E-02	0	.014338	-.072081	.066437	.6326	.83	.2004E+04	.6543E+01
2	2	3265E-02	0	.040931	-.041108	.066437	.6326	.83	.2004E+04	.6543E+01
3	3	3265E-02	0	.061108	-.041108	.066437	.6326	.83	.2004E+04	.6543E+01
4	4	3265E-02	0	.072081	-.014338	.066437	.6326	.83	.2004E+04	.6543E+01
5	5	3265E-02	0	.072081	.014338	.066437	.6326	.83	.2004E+04	.6543E+01
6	6	3265E-02	0	.061108	.040931	.066437	.6326	.83	.2004E+04	.6543E+01
7	7	3265E-02	0	.040931	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
8	8	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
9	9	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
10	10	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
11	11	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
12	12	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
13	13	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
14	14	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
15	15	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
16	16	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
17	17	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
18	18	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
19	19	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
20	20	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
21	21	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
22	22	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
23	23	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
24	24	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
25	25	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
26	26	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
27	27	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
28	28	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
29	29	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
30	30	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
31	31	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
32	32	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
33	33	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
34	34	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
35	35	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
36	36	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
37	37	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
38	38	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
39	39	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
40	40	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
41	41	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
42	42	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
43	43	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
44	44	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
45	45	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
46	46	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
47	47	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
48	48	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
49	49	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
50	50	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
51	51	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
52	52	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
53	53	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
54	54	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
55	55	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
56	56	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
57	57	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
58	58	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
59	59	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
60	60	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
61	61	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01
62	62	3265E-02	0	.014338	.072081	.066437	.6326	.83	.2004E+04	.6543E+01

```

63 63 4 .1910E-01 .25447 -30665 -750428 -.0457 0.00 0.
64 64 0 -.1910E-01 -.091194 .450461 .750420 .0457 0.00 0.

FD = -.308730E+03 FM = -.524924E-07 SPM = -.4501130E-07 SMZ = 0.
CD = .265187A CN = -.40000000 MY = -.00000000 WZ = 0.00000000
FX = 0.
FY = 0.00000000

```

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STEP      17   NEPTM = .440010   TIME = .016503   DIMENSIONLESS TIME .7325139   WETTING FACTORS = 1.0671000 1.8615000  
AVERAGE VELOCITY 0.000   -2.000   WA 0.000   VENTILATION 90.000
```

NO.	REF.NO.	WON	AREA	P	Y	Z	10	CP	P	FORCE
1	1	0	3265F-02	014374	-017281	065037	0795	01	1967E+04	6621E+01
2	2	0	3265F-02	004071	-004104	065037	0795	01	1967E+04	6621E+01
3	3	0	3265E-02	001104	-004031	066037	0794	01	1967E+04	6621E+01
4	4	0	3265E-02	072001	-010334	066037	0795	01	1967E+04	6621E+01
5	5	0	3265E-02	072001	-010334	066037	0795	01	1967E+04	6621E+01
6	6	0	3265F-02	001104	-004031	066037	0795	01	1967E+04	6621E+01
7	7	0	3265E-02	004031	-004104	066037	0795	01	1967E+04	6621E+01
8	8	0	3265E-02	014334	-017281	066037	0794	01	1967E+04	6621E+01
9	9	0	3265F-02	031040	-056150	154006	0003	59	1420E+04	1180E+02
10	10	0	3265F-02	004037	-013274	154006	0003	59	1420E+04	1180E+02
11	11	0	3265E-02	132374	-004052	154006	0003	59	1420E+04	1180E+02
12	12	0	3265F-02	156140	-0031060	154006	0003	59	1420E+04	1180E+02
13	13	0	3265E-02	156140	-0031060	154006	0003	59	1420E+04	1180E+02
14	14	0	3265F-02	132374	-004052	154006	0003	59	1420E+04	1180E+02
15	15	0	3265F-02	004037	-013274	154006	0003	59	1420E+04	1180E+02
16	16	0	3265E-02	004037	-013274	154006	0003	59	1420E+04	1180E+02
17	17	0	1147E-01	004037	-013274	154006	0003	59	1420E+04	1180E+02
18	18	0	1147E-01	004037	-013274	154006	0003	59	1420E+04	1180E+02
19	19	0	1147E-01	004037	-013274	154006	0003	59	1420E+04	1180E+02
20	20	0	1147E-01	004037	-013274	154006	0003	59	1420E+04	1180E+02
21	21	0	1147E-01	004037	-013274	154006	0003	59	1420E+04	1180E+02
22	22	0	1147E-01	004037	-013274	154006	0003	59	1420E+04	1180E+02
23	23	0	1147E-01	004037	-013274	154006	0003	59	1420E+04	1180E+02
24	24	0	1147E-01	004037	-013274	154006	0003	59	1420E+04	1180E+02
25	25	0	1147E-01	004037	-013274	154006	0003	59	1420E+04	1180E+02
26	26	0	1147E-01	004037	-013274	154006	0003	59	1420E+04	1180E+02
27	27	0	1147E-01	004037	-013274	154006	0003	59	1420E+04	1180E+02
28	28	0	1147E-01	004037	-013274	154006	0003	59	1420E+04	1180E+02
29	29	0	1147E-01	004037	-013274	154006	0003	59	1420E+04	1180E+02
30	30	0	1147E-01	004037	-013274	154006	0003	59	1420E+04	1180E+02
31	31	0	1147E-01	004037	-013274	154006	0003	59	1420E+04	1180E+02
32	32	0	1147E-01	004037	-013274	154006	0003	59	1420E+04	1180E+02
33	33	0	1595E-01	070115	-004037	051159	3595	04	1020E+03	1630E+01
34	34	0	1595E-01	070115	-004037	051159	3595	04	1020E+03	1630E+01
35	35	0	1595E-01	070115	-004037	051159	3595	04	1020E+03	1630E+01
36	36	0	1595E-01	070115	-004037	051159				

55	55	0	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
56	56	0	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
57	57	0	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
58	58	0	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
59	59	0	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
60	60	0	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
61	61	0	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
62	62	0	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
63	63	0	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
64	64	0	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
65	65	1	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
66	66	1	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
67	67	1	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
68	68	1	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
69	69	1	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
70	70	1	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
71	71	1	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.
72	72	1	1035E-01	244436	345324	550548	1835	0.00	0.	0.	0.

FX = 0. FD = .370349E+03 FN = -.538149E-07 SMZ = 0. SMY = 0. 0.0000000
CX = 0.0000000 CD = .1944462 CM = -.0000000 MX = -.0000000 MY = 0.0000000 WZ = 0.0000000

EXAMPLE 4

*****PROGRAM OPTIONS*****
 CONSTANT BODY ORIENTATION
 NO-WT PRINT
 SYMMETRIC CONFIGURATION

*****PROBLEM PARAMETERS*****
 DIAMETER .2500 FT
 ENTRY VELOCITY 100.000(F7/SEC)
 BODY ORIENTATION ANGLE 48.00 DEGREES
 INITIAL DEPTH .12500 FT TERMINATION STEP 1
 INITIAL PRESSURE CORRECTION FACTOR = 1.0000

CENTROIDE COORDINATES 0.00000 0.00000 0.00000
 INCREMENT IN DEPTH .0125000
 ANGLE OF ATTACK 0.00
 YAW ANGLE 0.00

WETTING FACTORS
 1.45000

*****GRID OPTIONS*****
 STANDARD
 LIST

MODE	GRID SIZE			NUMBER
	X	Y	Z	
1	0.0000	-0.2500	0.0000	1
2	-0.0217	-0.1250	0.0000	4
3	-0.0217	-0.1250	0.0000	7
4	-0.0000	-0.0250	0.0000	1
5	0.0000	-0.0250	0.0000	4
6	-0.0177	-0.0177	0.0000	7
7	-0.0250	-0.0000	0.0000	1
8	-0.0177	-0.0177	0.0000	4
9	-0.0000	-0.0250	0.0000	7
10	0.0000	-0.0750	0.0000	1
11	-0.0510	-0.0530	0.0000	4
12	-0.0750	-0.0000	0.0000	7
13	-0.0510	-0.0530	0.0000	1
14	-0.0750	-0.0000	0.0000	4
15	0.0000	-0.0750	0.0000	7
16	-0.0375	-0.0676	0.0000	1
17	-0.0546	-0.0468	0.0000	4
18	-0.0731	-0.0167	0.0000	7
19	-0.0731	-0.0167	0.0000	1
20	-0.0506	-0.0468	0.0000	4
21	-0.0375	-0.0676	0.0000	7
22	-0.0000	-0.0750	0.0000	1
23	0.0000	-0.1250	0.0000	4
24	-0.0542	-0.1126	0.0000	7
25	-0.0977	-0.0770	0.0000	1
26	-0.1219	-0.0278	0.0000	4
27	-0.1219	-0.0278	0.0000	7
28	-0.0977	-0.0770	0.0000	1
29	-0.0542	-0.1126	0.0000	4
30	-0.0000	-0.1250	0.0000	7
31	0.0000	-0.0000	0.0000	1
32	1.2200	-3.4500	1.2200	4

MODE

ELEMENT	1	2	3	4	XC	YC	ZC	RC	TC	AREA
33	1.8500	-2.1000	3.2300	1.9500	-3.119	3.7048				
34	1.7548	-4.100	3.2300	1.7500	1.1517	2.9398				
35	.9940	-4.500	3.2300	.9900	1.8965	2.5098				
36	.8000	-5.700	3.2300	.8000	2.8870	2.3998				
47	.6400	-8.000	3.2300	.6400	2.1996	2.3348				
38	0.0000	-9.000	3.2300	0.0000	2.2862	2.2848				

STEP 1 COMPLETE.CP TIME FOR STEP IS 4.43100
 STEP 2 COMPLETE.CP TIME FOR STEP IS 4.14700
 STEP 3 COMPLETE.CP TIME FOR STEP IS 4.02600

STEP 2 DEPTH = .1500000 TIME = .0011945 DIMENSIONLESS TIME .4770071 WETTING FACTOR = 1.4500000

NO.	REF.	NO.	MOD	AREA	X	Y	Z	T ²	CP	P	FORCE
1	1	0	0	.0119E-03	.009622	.000000	.000000	.2707	1.72	.1670E+05	.1356E+02
2	2	0	0	.1768E-02	.019151	-.046234	-.000000	.2951	1.81	.1776E+05	.3139E+02
3	3	0	0	.1768E-02	.046234	-.019151	-.000000	.2482	1.73	.1600E+05	.2970E+02
4	4	0	0	.1768E-02	.046234	.019151	.000000	.3092	1.63	.1582E+05	.2796E+02
5	5	0	0	.1768E-02	.015151	.046234	.000000	.3524	1.54	.1531E+05	.2706E+02
6	6	0	0	.2169E-02	.022146	-.097829	-.000000	.1242	2.06	.2002E+05	.4342E+02
7	7	0	0	.2169E-02	.062052	-.077011	-.000000	.1544	1.89	.1834E+05	.3979E+02
8	8	0	0	.2169E-02	.089643	-.043102	-.000000	.2099	1.70	.1651E+05	.3583E+02
9	9	0	0	.2169E-02	.089524	.000000	.000000	.2787	1.53	.1483E+05	.3217E+02
10	10	0	0	.2169E-02	.089648	.043102	.000000	.3475	1.43	.1387E+05	.3008E+02
11	11	0	0	.2169E-02	.062052	.077011	.000000	.4026	1.37	.1330E+05	.2886E+02
12	12	0	0	.2169E-02	.022146	.097029	.000000	.4333	1.35	.1309E+05	.2839E+02

FX = 0. FD = .7364194E+03 FN = .6222035E-07 CPY = -.5581771E+01 SMY = 0. SNZ = 0.
 CY = 0.0000000 CD = 1.5466035 CN = .0000000 MX = -.0468933 MY = 0.0000000 MZ = 0.0000000

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